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Bioaccumulation Potential of Contaminants from Bedded and Suspended Oakland Harbor Deepening Project Sediments to San Francisco Bay Flatfish and Bivalve Mollusks

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Prepared for U.S. Army Engineer District, San Francisco

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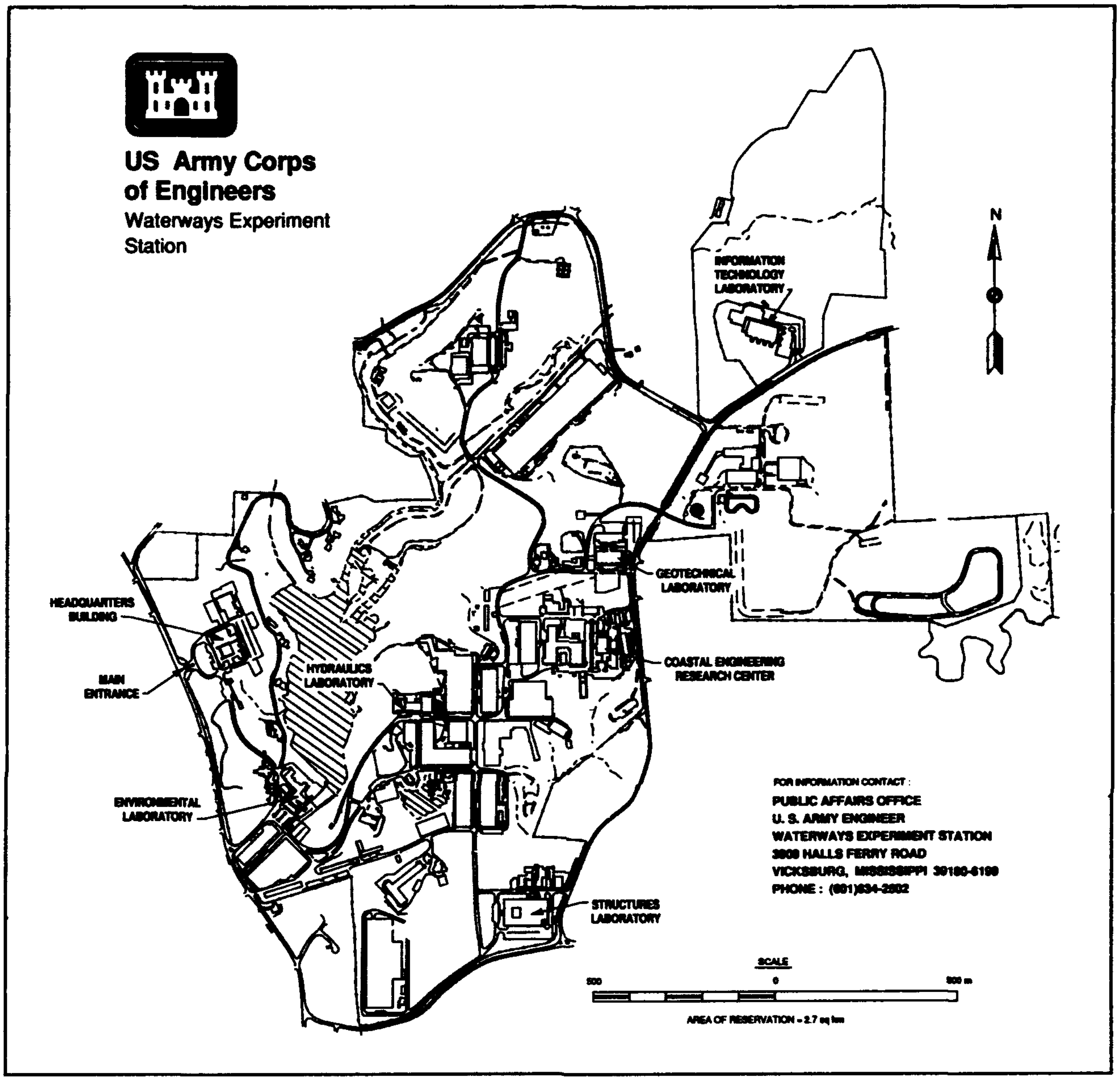

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Preface

This report was prepared for the U.S. Army Engineer District, San Francisco, by the U.S. Army Engineer Waterways Experiment Station (WES), Environmental Laboratory (EL).

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This report was written by Dr. Victor A. McFarland, Ms. Joan U. Clarke, Mr. Charles H. Lutz, and Ms. A. Susan Jarvis of the Fate and Effects Branch (FEB), EL, Mr. Brian Mulhearn (Environmental and Safety Designs, Inc., and Mr. Francis J. Reilly, Jr. (ENSERCH Environmental Corporation). The work was performed under the general supervision of Dr. Bobby L. Folsom, Jr., Chief, FEB. The Chief of the Environmental Processes and Effects Division was Mr. Donald L. Robey and the Director of the Environmental Laboratory was Dr. John Harrison.

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Summary

Sediments dredged to facilitate navigation in the San Francisco Bay-Delta system have historically been disposed by discharge at designated in-Bay dispersive open water sites. Recently, the public and local resource agencies have expressed concerns over the potential for mobilization of sediment-bound contaminants following dredging and disposal operations. Because of public opposition, proposed deepening of the Oakland Inner and Outer Harbor channels has been on hold since 1987. The study described in this report was designed to address the potential for contaminant uptake through exposures to suspended and bedded Oakland Harbor Deepening Project (OHDP) Inner and Outer sediments. Bioaccumulation that occurred from these sediments was put into perspective with bioaccumulation from sediments normally resuspended in the Bay by natural processes (Reference sediment), and from a demonstrably contaminated sediment (Oakland Hot).

Indigenous San Francisco Bay organisms, including an epibenthic flatfish (*Citharichthys stigmaeus*), an infaunal sediment-ingesting clam (*Macoma nasuta*), and a suspension-feeding mussel (*Mytilus edulis*), were exposed together to either bedded sediment or suspended sediment in replicate experimental units of the controlled-environment Flow-Through Aquatic Toxicology Exposure System (FATES) at the WES. A photoperiod, temperature, and salinity regime typical of summer in San Francisco Bay was used. Tissues were sampled immediately prior to each experimental run, and again after 28 days exposure. Each of the four sediments (Inner, Outer, Hot, and Reference) was tested in a separate experimental run.

Sediments and tissues were analyzed for a suite of contaminants, including organotins, polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides and DDE, and ten metals. The following contaminants were considered to be present in sufficient concentrations in one or more of the sediments to warrant concern: tributyltin and dibutyltin, PAHs, the PCB mixture Aroclor 1254, and the metals cadmium, chromium and mercury. Contaminant concentration data were compared statistically among sediments, species, or treatments.

The initial expectation was that contaminant concentrations would be highest in Hot and lowest in Reference. With a few exceptions such as Hg and Cr, contaminant concentrations were higher, sometimes much higher, in Hot than in the other sediments. Concentrations of all of the PAHs, for example, were one to three orders of magnitude higher in Hot than in the other sediments. The Inner sediment tended to have the lowest contaminant concentrations. Reference and Outer contaminant concentrations were often comparable. Contaminant concentrations in the four sediments were generally within the ranges reported for other San Francisco Bay sediments, and were far below the concentrations reported for degraded industrial harbors in the Northeast.

Bioavailability of contaminants from each of the four sediments was determined by comparing tissue concentrations in each of the three species (clams, mussels, fish) after 28 days exposure with background tissue concentrations taken immediately prior to the start of exposure. Bioavailable contaminants from the OHDP sediments were limited to Cd (Outer), Cr (Inner and Outer), and tributyltin (Inner). About half of the contaminants of concern were bioavailable from Reference, and all of them from Hot. Not only the number of contaminants bioaccumulated, but also the relative magnitude of uptake of most contaminants, were substantially greater from Hot than from the other sediments.

The mollusks generally accumulated contaminants to higher levels than the flatfish. Most contaminants that bioaccumulated achieved remarkably similar tissue concentrations, particularly in the clams, from either bedded or suspended sediment exposures. Mussels, which had no direct contact with the bedded sediment, bioaccumulated PAHs to higher levels from the suspended Hot sediment than from the bedded Hot sediment exposures.

Observed accumulation factors, AFs, (the ratio of lipid-normalized tissue contaminant concentrations to organic carbon-normalized sediment contaminant concentrations) for bioaccumulation of PAHs from the Hot and Reference sediments were much lower than predominantly PCB-based AFs previously calculated from field exposures. However, agreement with other studies measuring PAH AFs was good. It appears that sediment-chemistry based estimations of bioaccumulation potential would benefit from using chemical-specific AFs such as these.

Results of this bioaccumulation study suggest that disposal of OHDP Inner and Outer sediments at in-Bay aquatic disposal sites is unlikely to increase contaminant bioaccumulation above that which already occurs from naturally resuspended sediments.

Historical background, study objectives, methods, results, and conclusions are described in the body of this report. Mean contaminant concentration data, along with the results of statistical comparisons, are tabulated in full in Appendix A. Appendix B provides figures illustrating mean concentrations and comparison results for the contaminants of concern. For convenience, a notation is supplied in Appendix C.

Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
cubic yards	0.7646	cubic meters
feet	0.3048	meters

1 Introduction

Sediments dredged to create and maintain the system of ship channels, harbors, and marinas in the San Francisco Bay-Delta system have historically been disposed by discharge at designated in-Bay dispersive open-water sites. The annual volume of sediments dredged for maintenance purposes now stands at about seven million cubic yards (mcy)[1], and channel improvement projects authorized by Congress, but not yet begun, will require dredging an additional 19 mcy (Wakeman, Chase, and Roberts 1990). In 1972 the USACE, San Francisco District (SFD), cut the number of in-Bay disposal sites from 11 to 5 in an effort to limit the amount of redredging then being required due to the proximity of disposal to the channel. Subsequently, this number was reduced to three sites located in the Carquinez Straits, San Pablo Bay, and in the Central Bay near Alcatraz Island. By far the most heavily used for dredged material disposal has been the Alcatraz site, receiving more than 60 percent of the total material dredged in the Bay system. All of the sediments removed by maintenance dredging in Oakland Harbor have been discharged at Alcatraz.

In 1982 it became evident that the Alcatraz site was no longer dispersing all of the discharged material. Efforts were made to recover the dispersive capability of the site, but ultimately failed. With the realization that the capacity of the Alcatraz site to accept dredged material was finite, State and Federal resource management agencies as well as concerned citizens' groups began to question the biological impact of the accumulated sediments at Alcatraz (Wakeman, Chase, and Roberts 1990). When sediments were slurried prior to discharge to facilitate dispersal, the visible increase in turbidity that resulted raised concerns about the potential effects of suspended sediment on the Bay's ecosystem. One such concern was the potential for sediment-bound contaminants to be remobilized and made available to indigenous organisms within the Bay.

In early 1987, SFD prepared to begin maintenance dredging of Oakland Inner and Outer Harbor. The authorized plan for the Oakland Harbor Deepening Project (OHDP) proposed to deepen Oakland Inner and Outer Harbor channels from 35 to 42 ft below mean low lower water (MLLW), and in the process, to generate 7.0 mcy of dredged material. The dredged sediments were to be discharged at the Alcatraz site[2]. For the 42 ft project, maintenance dredging would then require annually dredging an additional 158,000 cy that would also be taken to the Alcatraz site. However, the California Regional Water Quality Control Board (RWQCB) denied water quality certification for the OHDP, stating concern about "...possible contamination of bay sediments from commercial, industrial, and military land use" (RWQCB letter to USACE SFD dated 19 February 1987). Likewise, public reaction to the draft environmental impact statement prepared by SFD for the OHDP stressed concerns over the

[1] A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page xiii.

[2] In 1992, the Inner Harbor channel was deepened to 38 feet below MLLW. 500,000 cy of material met the criteria set by the Ocean Disposal Testing manual (the "Green Book," USEPA/USACE 1991) for disposal in open water, and was placed at Alcatraz; 20,000 cy did not meet the Green Book criteria, and was placed at an upland site.

potential for mobilization of sediment-bound contaminants following disposal of OHDP dredged material.

In response, the SFD requested technical assistance from the USAE Waterways Experiment Station (WES). A literature search undertaken to assess the degree to which expressed concerns were valid or mistaken was unable to provide conclusive answers (McFarland et al., in review). The WES Environmental Laboratory (EL) proposed research to address two areas of concern: toxicity and bioaccumulation (McFarland and Dillon 1987). The toxicity research was intended to assess the potential chronic effects of contaminated OHDP sediments on growth and reproduction in the benthic infaunal polychaete, *Nereis (Neanthes) arenaceodentata*, a species indigenous to San Francisco Bay. The bioaccumulation work was intended to address the potential for contaminant uptake through exposures of native estuarine species to suspended and bedded OHDP sediments. Any bioaccumulation that occurred would be put into perspective with bioaccumulation from sediments normally resuspended in the Bay by natural processes. The objectives of the two research areas, chronic toxicity and bioaccumulaton, were specifically linked to changes that had occurred at the Alcatraz site and the potential impact of disposal of the proposed OHDP sediments there.

At the same time chronic toxicity and bioaccumulation studies were being conducted by the WES, Battelle Marine Science Laboratory, under contract to SFD, undertook bioassay testing of the OHDP sediments using methods newly revised in the Green Book. The impetus for the work by Battelle was the request made by the RWQCB that SFD conduct testing of the Oakland Harbor maintenance and OHDP sediments according to procedures for ocean disposal. In the interests of cost saving and comparability, sediment collection for the WES and Battelle projects was conducted jointly as were many of the chemical analyses performed on sediment and tissue samples. Results of the Green Book bioassays have now been reported (Kohn et al. 1992, Ward et al. 1992), as have the results of the chronic toxicity study (Moore and Dillon 1992). This report presents the results of the bioaccumulation studies.

2 Bioaccumulation Study Objectives

The laboratory experiments were intended to provide answers to the following questions:

a. Are contaminant concentrations in OHDP Inner or Outer Harbor sediments significantly different from those in sediments that are typically suspended in the Central Bay by natural processes?

b. Are contaminant concentrations in OHDP Inner or Outer Harbor sediments significantly different from concentrations in sediments that are demonstrably contaminated?

c. Are contaminants in any of the sediments bioavailable to indigenous organisms?

d. Do certain types of organisms bioaccumulate contaminants to higher levels than other organisms?

e. Do organisms exposed to suspended OHDP sediment bioaccumulate contaminants to a significant extent as compared with organisms exposed to the same sediment when it is bedded?

f. Do organisms exposed to either bedded or suspended OHDP sediments bioaccumulate contaminants:

(1). To levels comparable with those resulting from exposure of organisms to a recognizably contaminated harbor sediment?

(2). To a greater or lesser extent than organisms exposed to surficial sediments typical of the material naturally suspended in the Bay by wind or storm action?

3 Methods and Materials

Approach

In a series of laboratory experiments, indigenous SF Bay organisms were exposed to suspended and bedded OHDP sediments under environmental conditions characteristic of the Alcatraz Island Disposal Site. Contaminant uptake was measured in organisms exposed to four composited sediments. Two of the composites represented sediments of the OHDP: one from stations selected in OHDP Inner Harbor ("Inner"), and one from OHDP Outer Harbor ("Outer"). These were contrasted with uptake from a known contaminated sediment, OHDP Hot ("Hot"), and from a sediment representative of material normally suspended in the Central Bay by wind or storm action, Berkeley Flats Reference ("Reference"). The Hot sediment was taken from an area that had previously been shown by chemical analysis to have elevated concentrations of metals and organic contaminants, and was toxic to organisms in bioassays (Word *et al.* 1988). The Reference sediment consisted of surficial material from shoal areas in the eastern reaches of the Central Bay. All locations for sediment sampling were selected by SFD with input from interested State and Federal Agency personnel.

The WES EL Flow-through Aquatic Toxicology Exposure System (FATES) was used to provide the exposures. FATES is an advanced version of the Turbidity Bioassay Facility developed at the University of California Bodega Marine Laboratory and used in the San Francisco Bay Dredge Disposal Study during the 1970s (McFarland and Peddicord 1980; Peddicord et al. 1975; Peddicord and McFarland 1976, 1978). The system has since been used in several other investigations involving contaminant bioavailability and bioaccumulation from natural sediments (Clarke, Lutz, and McFarland 1988; Lee et al. in press; McFarland and Clarke 1986; McFarland, Clarke, and Gibson 1985; McFarland, Gibson, and Meade 1984; McFarland and Peddicord 1986).

The FATES was configured to provide exposures to either bedded sediment or suspended sediment. Organisms representing different relationships with bedded and suspended sediment were chosen. These consisted of an epibenthic flatfish, an infaunal sediment-ingesting clam, and a suspension-feeding mussel. The three species were exposed together in each experimental unit, and replicate exposures were conducted. A typical summer photoperiod, temperature, and salinity regime was used, and the exposures were allowed to run for 28 days before sampling.

Four experiments were conducted in sequence during the summer and fall months over a two-year period. Each experiment used the same experimental design and required three months for setup, collection and acclimation of organisms, exposure, and takedown. The first and second experiments tested the Inner and Outer sediments, respectively. If bioaccumulation had not been observed in organisms exposed to one of these sediments, no further testing would have been conducted. Some

bioaccumulation was observed, and the third and fourth experiments were conducted the second year, testing the two reference sediments, Hot and Reference.

Sediment Collection and Preparation

All sediments were collected by Battelle/Marine Sciences Laboratory (MSL), Sequim, Washington, under contract to USAE SFD. Collection expeditions were scheduled to precede FATES exposure experiments by 1-2 weeks to minimize storage time before use of each sediment. Collection locations are shown in Figure 1. Inner consisted of composited cores from stations IC-1 to IC-18. Outer consisted of composited cores from stations OC-1 to OC-13. Hot consisted of composited cores from two stations, IT-6 and IM-1. Details of the location of sample sites (except IM-1) and the collection methods used can be found in Ward et al. (1992). Station IM-1 was located in the maneuvering area of Oakland Inner Harbor. Sediments from within the OHDP Harbor system (Outer, Inner, and Hot) were collected on separate expeditions using a 30.5-cm Vibratory Hammer Corer. Cores were sectioned aboard the vessel to obtain samples from depths representative of the deepening project (-38 to -42 ft MLLW). Total volume of each composite was 208 L. Cores were mixed in an epoxy-lined drum aboard the vessel and stored at 4°C. The Reference sediment was collected in a shoal area (2 to 3-m depth) of the East Bay using a benthic sled device that could be adjusted to skim the top few centimeters of sediment when towed behind a small boat. The intent was to collect only the sediment that would be resuspended during a wind or storm event in Central SF Bay. Sediments were collected at two sites, 122°19'18" W by 37°52'50" N and 122°18'40" W by 37°15'59" N. The material collected at the two sites was composited in an epoxy-lined 208 L drum.

Composites collected from Outer, Inner, and Hot locations were shipped by refrigerated truck to the WES. The Reference sediment composite was shipped to WES in insulated coolers via overnight air freight. All sediments received at the WES were stored at 4°C until used. During setup for each experiment a sediment composite was removed from cold storage, homogenized with a large hand-held electric mixer, and five replicate 1-L samples were taken for chemical analysis. In addition, approximately 19 L of each homogenized composite used for FATES experiments was shipped to Battelle/MSL for bioassays.

After homogenization, a high density slurry was created by mixing 455 L N_2-sparged artificial seawater with ≈ 133 L test sediment. The slurry was prepared by mixing water and sediment in a 755 L polyethylene tank using a high shear-speed disperser with 316 stainless steel impeller and shaft. The slurry was then passed through a 3-mm sieve to remove debris, and pumped into a 675-L stainless steel cone-bottom tank. The slurry was maintained under Ar_2 to prevent oxidation and was continuously recirculated within the tank with a low-velocity, high-volume, air-driven pump to prevent settling.

The remainder of the homogenized sediment (≈ 57L) was reserved for use as bedded sediment in the FATES.

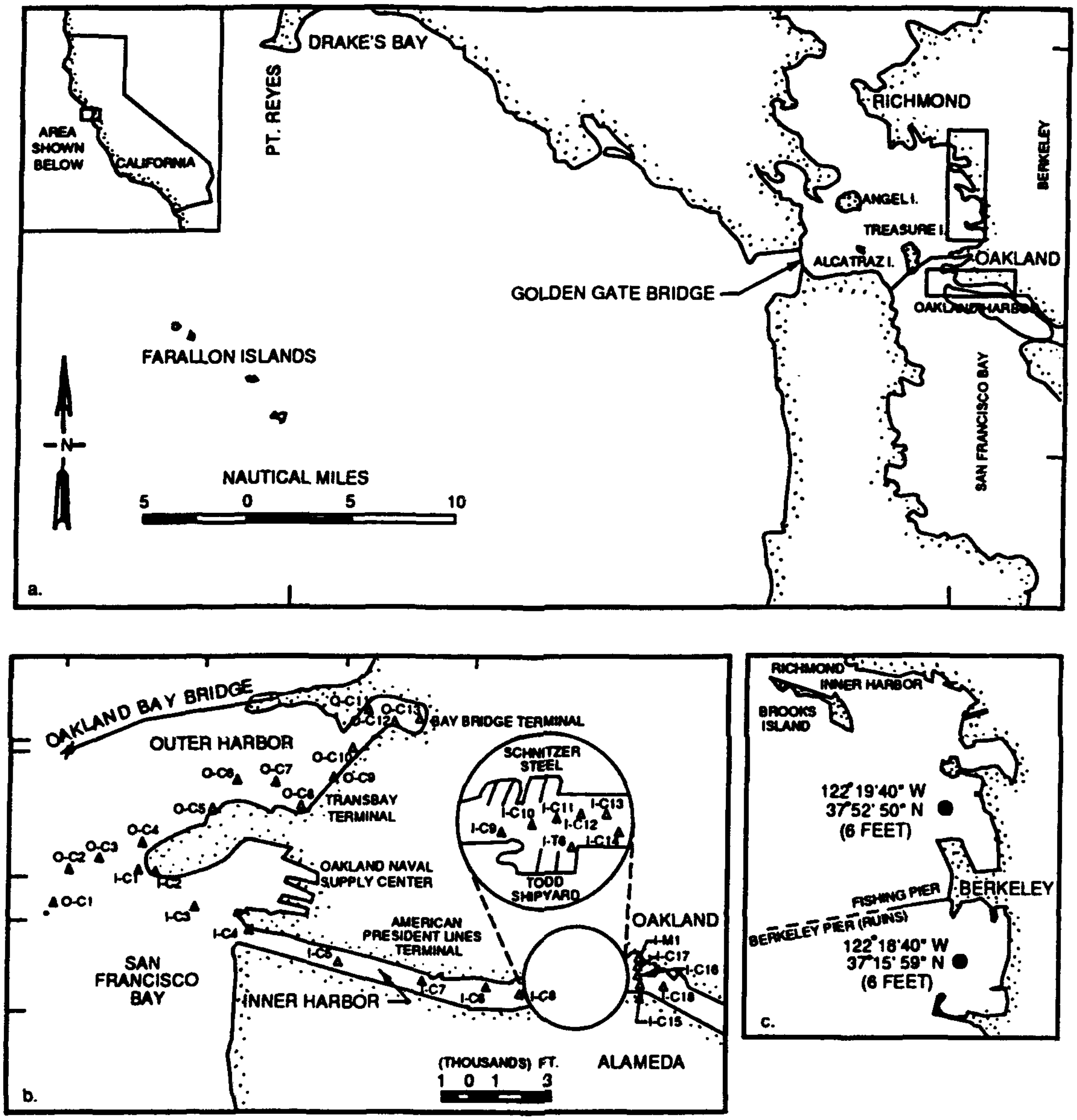

Figure 1. Sediment collection sites in Central San Francisco Bay. a. Oakland Harbor study area b. OHDP Inner, Outer, and Hot sampling locations c. Berkeley Flats Reference sample locations

System Description

The FATES is a unique large-capacity aquarium system capable of exposing aquatic organisms to suspended sediments maintained at constant concentrations, with continuous once-through replacement of water. It consists of 24 round-bottomed 75-L circular aquaria, each with its own recirculating pump and transmissometer probe (Figure 2). Clean water and test sediment slurry enter the aquarium through an inflow port at the top. Flow-through water replacement is established by the pulsed addition of clean make-up water and the removal of an equivalent volume through an overflow port opposite the point of water entry. Water is mixed and recirculated within each aquarium by withdrawal through a screened suction port at the side of the aquarium, pumped through the closed system heat exchanger and back into the bottom of the aquarium. All but the largest sediment particles are kept in suspension by the bottom-to-top current flow that results. A stainless steel screen floor prevents fish from having contact with particulate material that settles out of suspension. Two heat exchangers, each serving 12 aquaria, provide the dual function of removing heat introduced to the aquarium water by action of the recirculating pumps and maintenance of constant water temperature at the experimental setpoint. Each aquarium is independent of every other, allowing random assignment of controls, treatments, and replicates among the 24 experimental units. A microcomputer operating through a system of sensors and switching devices automatically regulates temperature, water flow rate, and suspended sediment levels. Temperature is monitored continuously and adjusted as needed by the computer. Suspended sediment levels in each aquarium are read periodically and adjusted to maintain concentrations within defined limits above and below the setpoint. Every 6 hr, temperature, dissolved oxygen, pH and conductivity data are reported for each aquarium. These data are stored on disc and automatically printed at set intervals, or on demand, allowing for continuous monitoring of the experimental conditions. Photoperiod and salinity are controlled externally.

All water used by the FATES is collected in a sump and is pumped through a particulate filter that removes a large fraction of the sediment particles from the water. This sediment is collected in a steel drum for disposal. The remaining sediment and water flows into a settling basin and the particle-free effluent is then pumped through a series of bag filters, activated carbon filters, and clay filters to remove solubilized contaminants. Settled sediments are periodically removed from the sump for waste disposal determined by the degree of contamination.

An alarm system installed on the FATES monitors water availability, electricity, compressed air, computer software errors, water temperature, and water conductivity. A system failure during unattended periods will result in a telephone summons to a system operator and an identification of the problem area. The computer and data acquisition systems are served by an uninterruptable power supply that provides electricity for a minimum of 8 hr during a power outage. The uninterruptable power supply and alarm system allow the FATES to run continuously for extended periods without risk of undetected major breakdowns.

System performance

During each experiment of the OHDP sediment study, gravimetric total suspended solids measurements (USEPA 1979) were performed three times weekly on each aquarium as a manual check on the

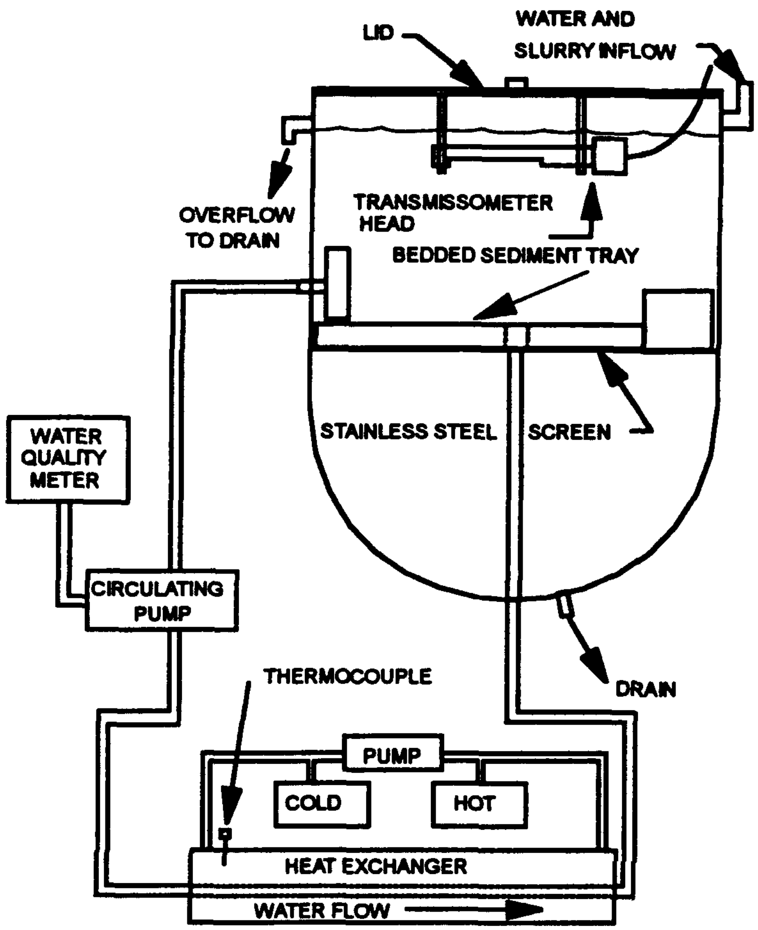

Figure 2. Schematic diagram of a single FATES aquarium

performance of the automated suspended sediment control system. Physical data (temperature, dissolved oxygen, and salinity) were also measured manually twice weekly and were compared with the computer monitored values. Discrepancies between the manual data and the computer data were verified and equipment calibrations performed as necessary.

Water supply

All four experiments were run at 30 ‰ salinity, necessitating mixing and storing large volumes of artificial seawater. Flow-through operation of the FATES required ≈ 5600 L water/day. A commercial marine aquarium sea salt (Instant Ocean™) was used to make up the experimental water. A stock brine solution of 90 ‰ sea salts was made using a high shear-speed mixer and was stored in a 7500-L polyethylene tank. As needed, water was automatically pumped from this tank to a second 7500-L tank and diluted with aged tap water to produce the required experimental salinity. Both storage tanks were internally recirculated to maintain salts in solution. The artificial seawater was pumped on demand through a sand filter to a small head tank and dispensed by a computer-timed valving system to the FATES aquaria.

Suspended sediment

A transmissometer probe mounted in the plexiglas lid of each aquarium read transmitted light at a depth of 8 cm at 15-min intervals. This measurement was compared with preset levels in a computer program and metered amounts of stock slurry were added to maintain suspended sediment concentrations near the setpoint. Setpoints were established before the start of exposures by calibrating transmissometer output against simultaneous gravimetric measurement of total suspended solids in each aquarium.

Organisms

One fish and two invertebrate species were selected as representative of native estuarine organisms that are abundant, include the major feeding types and associations with bedded and suspended sediments, and are ecologically and/or commercially important in SF Bay. The Bay or blue mussel, *Mytilus edulis*, is strictly a filter-feeding bivalve that filters large volumes of water (>3 L/hr) and by so doing concentrates chemical contaminants found in the water column. It colonizes hard surfaces such as exposed rocks, piers, and pilings in the high intertidal zone (Shaw, Hassler, and Moran 1988; Newell 1989) and forms dense fouling communities, attaching to surfaces and to other individuals by byssal threads. *M. edulis* is preyed upon by sea stars, gastropods, marine mammals, and birds, and supports a minor sport fishery. *M. edulis* is normally exposed to sediments only when they are suspended in the water column.

Speckled sanddabs, *Citharichthys stigmaeus*, are flatfish that prefer substrates of fine sand or sandy mud containing broken shell and foreign objects that provide irregularities in the bottom. These preferences lead to high densities of the fish around rocks and pilings in the SF Bay system. *C. stigmaeus* feed primarily on benthic, epibenthic, and nektonic crustaceans. Sanddabs pick their food cleanly off the bottom without ingesting much sedimentary material (Rackowski and Pikitch 1989). The fish has direct cutaneous contact with bedded and with suspended sediments, but ingests little of either.

The bent-nosed clam, *Macoma nasuta*, is primarily a deposit-feeder, but depending on food availability will also filter-feed. It is an infaunal organism that burrows in sediments and uses its inhalant siphon to browse the sediment surface around its burrow, or to filter the overlying water. On the West Coast, *M. nasuta*'s range extends from Alaska to Baja California and its habitat is sandy to muddy sediments of the littoral zone to depths of about 50 m (Hylleberg and Gallucci 1975, Levinton 1991). Of the three species used in this study, *M. nasuta* has the most intimate contact with bedded sediment since its lifestyle involves burrowing into and actively ingesting the sediments.

All organisms were collected from uncontaminated waters north of SF Bay (Brezina and Associates, Dillon Beach, CA). The animals were shipped by air express to the WES and acclimated to experimental conditions for several weeks before the beginning of each experiment.

Acclimation

The acclimation facility consisted of a photoperiod- and temperature-controlled building separated from the experimental facilities. Organisms were maintained in fiberglass tubs in artificial seawater at 30 ‰. The water was changed regularly and sick or dead animals removed. Sanddabs were fed a dry flake fish food and the bivalves received a commercial liquid invertebrate diet. Organisms generally gained weight during acclimation. Only healthy animals were used in the experiments.

Exposure conditions

The environmental conditions established for all of the OHDP bioaccumulation experiments were 30 ‰ artificial seawater, 15°C water temperature, and a 12 hr/12 hr day/night light cycle over

28 days of exposure. A flow-through water replacement mode was maintained with ≈ 350 ml seawater entering each aquarium every two min. This rate of delivery produced one complete water turnover every eight hours. Enough animals were placed in each aquarium so that even with some deaths at least 50 grams of tissue were available at the end of the exposure. The approximate numbers of organisms used in each aquarium for the four experiments were 80 fish, 20 mussels, and 20 clams. Numbers of fish varied with average fish size, ranging 55 to 99 fish per aquarium. Dead or injured individuals were removed and organisms were fed dry flake fish food and liquid invertebrate diet during daily visual inspections.

At the end of the exposure periods, organisms were allowed to purge in clear flowing water for 24 hr to eliminate ingested or entrained sediment. After purging, clams and mussels were shucked, the shells discarded, and species from an aquarium were pooled separately in clean glass jars. All tissue samples were preserved for analysis by freezing.

Experimental Design

In each of the experiments, the 24 aquaria of the FATES were randomly assigned the following treatments and replications (Figure 3):

a. BS: Bedded test sediment with clear water flow through, six replicates.

b. S10: Flow-through suspension of test sediment fines at approximately 10 mg/L without bedded test sediment, six replicates.

c S50: Flow-through suspension of test sediment fines at approximately 50 mg/L without bedded test sediment, six replicates.

d. NC: Laboratory (negative) controls, three replicates.

e. PC: Positive controls, three replicates.

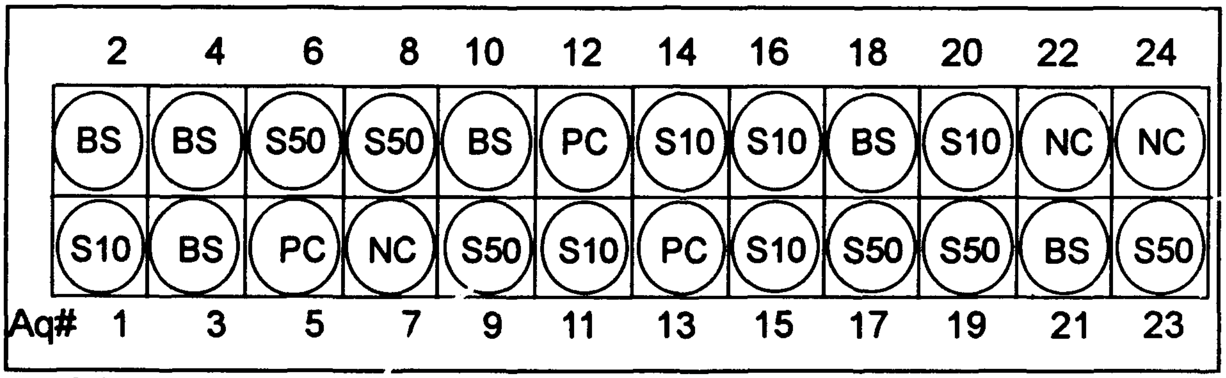

Figure 3. Schematic of FATES random treatment layout

Aquarium configurations for bedded and suspended sediment treatments

The 24 aquaria were configured to provide simultaneous exposure to the three species in an environment containing either bedded test sediment or suspended test sediment, but not both. The mussels were kept in course-mesh net containers near the top of an aquarium (Figure 4). Clams were allowed to bury themselves in mesh-covered sediment trays. Fish were free to swim in the aquaria and to settle on the sediment surface in the bedded sediment treatments, or the perforated stainless steel aquarium floor in suspended sediment treatments.

Bedded sediment treatment (BS)

A 46-cm-diam plexiglass tray, 5-cm deep in the open sediment area, and 10 cm deep in the screened clam area (Figures 4 and 5a) was filled to a depth of ≈ 2 cm (open area) and 6 cm (screened area) with test sediment, and was placed on the stainless steel mesh floor of an aquarium. The clams were allowed to burrow in the deeper sediment section and a high density polyethylene netting (5-mm mesh) was fastened over them to prevent predatio˜ by the fish. Mussels were suspended in the upper water column in a polyethylene net bag. The fish were added last and their access to the bedded sediment was unrestricted. Only sediment suspended by the activity of the animals was found in the water column.

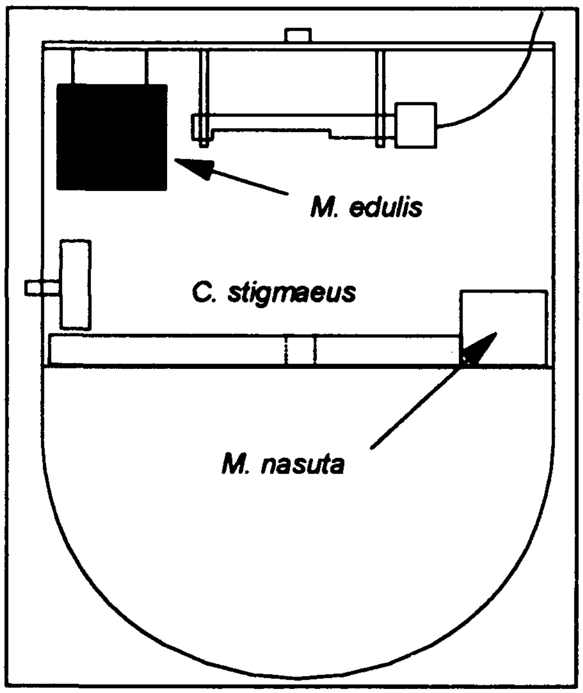

Figure 4. Location of animals in the FATES aquaria

Suspended sediment, 10 mg/L treatment (S10)

A 10 cm deep plexiglass compartment identical to the clam area of the sediment trays in the BS treatment was used (Figure 5b). The compartment was filled to a depth of ≈ 5 cm with uncontaminated sediment that had been collected with the clams. The compartment was covered with polyethylene netting and placed on the stainless steel mesh floor of the aquarium. Mussels were suspended in the water column in polyethylene mesh bags as in the BS treatment. Fish were free in the aquaria but denied access to any bedded sediment. The clams burrowed in the uncontaminated sediment but fed on the surface where some settling of the suspended test sediment occurred. The only contact the fish or mussels had with the test sediment was via the water column where suspended sediment levels were maintained at ≈ 10 mg/L.

Suspended sediment, 50-mg/L treatment (S50)

The same aquarium configuration was used as in the S10 treatment, and the concentration of suspended sediment in the water column was maintained at ≈ 50 mg/L.

Control treatments

Negative control (NC). Negative laboratory controls consisting of clear culture water over washed sand or gravel substrate were included as a check on the overall environmental quality of the system, and to detect any contaminant uptake by organisms due to the experimental facilities themselves. The aquaria were configured as for the suspended sediment exposures.

Positive control (PC). Positive controls were included as a means of verifying consistency between non-concurrent experiments. The positive controls consisted of clear culture water over inert substrate, as with the negative controls. Three bioaccumulating chemicals (DDT, phenanthrene, and cadmium) in seawater solution were continuously added to the PC aquaria using a chemical metering pump. The calculated dosage was sublethal, but sufficient to bioaccumulate.

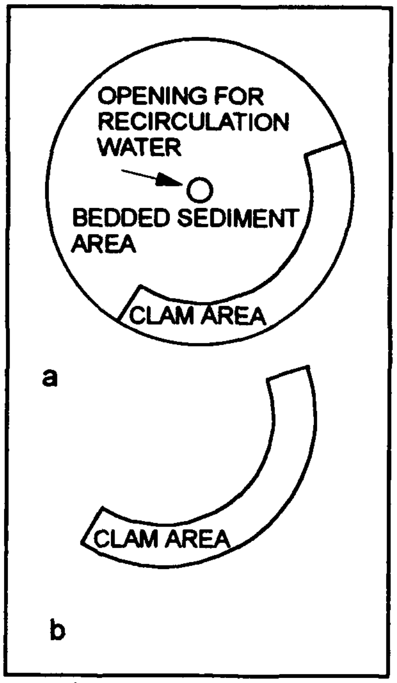

Figure 5. Top view of clear plexiglass trays used for different treatments. a. Bedded sediment exposures. b. Suspended sediment exposures

Analytes

The potential contaminants of the sediments specified for analysis by SFD were:

a. Organotins.

b. Polynuclear aromatic hydrocarbons (PAHs).

c. Pesticides and DDE.

d. Polychlorinated biphenyls (total PCB, Aroclors, and specific congeners).

e. Metals: Ag, As, Cd, Cr, Cu, Hg, Ni, Pb, Se, Zn.

Duration of exposures

The nature of the chemical contaminants that are most bioavailable in the sediments is the primary determinant of exposure duration in a residue comparison design. Organisms must bioaccumulate to levels sufficiently in excess of the detection limits as to provide consistent results enabling statistical comparisons. In most cases when complex mixtures of chemicals are present an exposure period of three weeks is enough. Four or six weeks may be necessary in the event that sediment analysis

discloses the presence of very low concentrations of slowly bioaccumulating substances such as highly chlorinated PCBs or pesticides. The scheduling in this investigation used an exposure duration of four weeks based on the analytes specified above.

Selection of samples for analysis

Five replicate aliquots of each of the sediment composites were analyzed for the full suite of chemicals listed above. The results were used to determine whether to analyze organisms exposed in the FATES to each sediment for each of the analytes. Tissue samples most likely to show bioaccumulation (S50) were analyzed first, and all others (S10, BS, NC and PC) taken at the same time were archived. Background (Day 0) tissue samples were also archived until uptake in the experimentally exposed organisms had been demonstrated.

A decision to analyze archived BS-exposed organisms followed if residues in the S50 organisms were judged high enough to warrant further investigation. A decision to analyze S10-exposed organisms was at the discretion of SFD, and depended on finding unexpectedly high chemical concentrations in the S50-exposed organisms. None of the S10-exposed organisms were subsequently analyzed. PC and Day 0 samples were analyzed for the same chemicals as the BS- and S50-exposed organisms. NC samples were not analyzed.

Chemical Analysis

Analyses of sediments and tissues were accomplished by Battelle Pacific Northwest Laboratories (BPNL), Richland, WA, and by the Analytical Laboratory Group (ALG) of the Environmental Laboratory, WES. Lipid analysis of tissues was performed by BPNL on samples they analyzed, or by the WES Aquatic Contaminants Team (ACT) on tissue samples analyzed by the WES/ALG. Identification of the samples, analytes, and laboratory responsible for the analysis is shown in Table 1.

Analysis of sediments

Organotins. *BPNL.* Butyltins were extracted with dichloromethane according to MSL-SOP-M-004 following the method of Unger et al. (1986). The extraction was performed using a roller under ambient conditions followed by derivatization using a Grignard reagent to change to a form compatible with gas chromatography (GC). Sample extracts were then cleaned by passing through a florisil column. Butyltins were analyzed using GC/flame photometric detection.

PAHs. *BPNL.* Sediment samples were extracted according to EPA Method 3540 (USEPA 1986) using dichloromethane. Extracts were analyzed for PAH compounds following EPA Method 8270 (USEPA 1986) using GC/mass spectrometry (MS) on a Hewlett Packard HP 5890 GC and a HP 5970 MS detector. The initial temperature was 35°C, which was increased at a rate of 6°C/min to the final temperature of 325°C. Helium was the carrier gas used at approximately 25 cm/sec flow-rate. A J&W DB-5 30 m x 0.25-mm i.d. (inner diameter) x 0.25-μm film thickness column was used.

Table 1
Analyses, Performing Laboratory, Sample Matrix, and Source of Samples.

Analyte	Laboratory	Sample Matrix	Source of Samples			
			Reference	Outer	Inner	Hot
Organotins	BPNL	Sediment	X	X	X	X
		Tissue	X	X		X
PAH	BPNL	Sediment	X	X	X	X
		Tissue	X			X
	WES/ALG	Sediment		X		
		Tissue		X	X	
Pesticides	BPNL	Sediment	X	X	X	X
		Tissue	X			X
PCB as Aroclors	BPNL	Sediment	X	X	X	X
		Tissue	X			X
	WES/ALG	Sediment		X		
		Tissue		X		
PCB Congeners	BPNL	Tissue	X			X
	WES/ALG	Sediment		X		
		Tissues		X		
Metals	BPNL	Sediment	X	X	X	X
		Tissue	X	X	X	X
	WES/ALG	Tissue		X		
Oil & Grease, Total PH	BPNL	Sediment	X	X	X	X
Total Organic Carbon (TOC)	BPNL	Sediment	X	X	X	X
DDT	BPNL	Tissue	X			X
	WES/ALG	Tissue		X	X	
Lipids	BPNL	Tissue	X			X
	WES/ACT	Tissue		X	X	

WES/ALG. Sediments were extracted for PAH and PCB/pesticide analysis using EPA method 3540 (USEPA 1979) using a 1:1 mixture of acetone:hexane. Extracts were cleaned up using silica gel columns for PAH analysis (Warner 1976). Following cleanup, the samples were concentrated to less than 1.0 ml. PAHs were analyzed by GC/MS according to EPA Method 8270 using a Hewlett Packard Ultra 2 column (crosslinked 5 percent phenylmethyl silicone) 25 m, 0.32-mm i.d., and 0..52-μm film thickness equivalent to a J&W DB-5 column. The volatiles were analyzed according to EPA Method 8240 except that a capillary column was used as recommended in EPA Method 8260. The column was a J&W DB-624, 30 m, 0.533-mm i.d. (megabore) with 3-μm film thickness. EPA method 8000 was used as quality assurance/quality control guidance for PAH/PCB/pesticide analysis.

Pesticides and PCBs. *BPNL.* Sediment samples were extracted according to EPA Method 3540 using dichloromethane, followed by an alumina and copper clean-up. PCBs and chlorinated pesticides were analyzed using GC/electron capture detection (ECD) according to Method 8080 (USEPA 1986). PCBs were quantified as Aroclors. All positive identifications were confirmed using a second dissimilar column. The instrument used was a Hewlett Packard 5890 GC using He as the carrier gas at a flow rate of approximately 25 cm/sec. The make-up gas was 95% argon/5% methane (P5), which was set at a flow rate of 40-50 ml/min. The initial oven temperature was 40°C, which was held for 1.5 min. The temperature was increased to 150°C at a rate of 10°C/min and was then increased to 280°C at a rate of 2°C/min and held for 10 min. The temperature of the detectors was 300°C and the injection port temperature was 225°C. Columns used were a J&W DB-5 30 m x 0.25 mm i.d. x 0.25 μm film thickness, and an SPB-608 as a dissimilar confirmation column of the same dimensions. Quantitation of over 80 individual PCB congeners was performed by using known concentrations of the congeners of interest in a specified mixed Aroclor standard (Mullin 1985) to calibrate the GC.

WES/ALG. Sediments were extracted as for PAHs. Extracts were cleaned up using Florisil columns (Mills et al. 1972). Following cleanup, the samples were concentrated to less than 10.0 ml under N_2 in a Zymark Turbovap™. USEPA Method 8080 (SW-846, 1986) was followed for analysis of PCB/pesticides using USEPA Method 3660 part 7.2 for sulfur cleanup with Hg (SW-846, 1986). Analyses for PCB/pesticides were performed on a Hewlett-Packard 5880 gas chromatograph. Splitless injection with dual capillary columns was used. The columns were a DB-5 30 m, 0.25 mm i.d. with 0.25 μm film thickness and an SPB-608 30 m, 0.25 mm i.d. with 0.25 μm film thickness. Carrier gas was He, and the make-up gas was P5. Oven temperature was 140°C initially, ramped at a rate of 1°C/min to 200°C and held for 12 min, then ramped at a rate of 2°C/min and held for an additional 12 min. Two ECD detectors were used, one on each column. Standards for total PCBs and Aroclor mixtures were Aroclors 1016, 1221, 1232, 1242, 1248, 1254 and 1260[1]. Standards for congeners were Canadian standard mixtures CLB-1A,B,C and D[2]. Pesticide standards were α-BHC, β-BHC, γ-BHC, δ-BHC, heptachlor, aldrin, heptachlor epoxide, α-chlordane, γ-chlordane, endosulfan sulfate, endosulfan I, endosulfan II, DDE, DDT, DDD, dieldrin, endrin, endrin aldehyde, endrin ketone, methoxychlor, and dibutylchlorendate (USEPA, Research Triangle Park, NC).

Metals. *BPNL.* Metals in sediments (Ag, As, Cd, Cr, Cu, Hg, Ni, Pb, Se, and Zn) were digested using a mixture of nitric/perchloric and hydrofluoric acids. Arsenic, Cr, Cu, Ni, Pb, and Zn

[1]Obtained From USEPA, Research Triangle Park, NC.

[2]Obtained from NRC-Canada.

were measured by energy-diffusive X-ray fluorescence following the method of Sanders (1992). Mercury was analyzed by cold vapor atomic absorption spectroscopy (CVAA) (Method 7471, USEPA 1986, Bloom and Crecelius 1983). Silver, Cd, and Se were analyzed by Zeeman graphite furnace atomic absorption spectroscopy (GFAA) (Method 7000 Series, USEPA 1986, Bloom and Crecelius 1987).

Oil and grease, total petroleum hydrocarbons. *BPNL.* Oil and grease were determined according to Method 413.2 (USEPA 1983). Sediment samples were extracted with freon and filtered. Extracts were analyzed using an IBM IR/42 Fourier transform infrared spectrometer. Total petroleum hydrocarbons were determined according to Method 418.1 (USEPA 1983). Sediment samples were extracted with freon. Silica gel was added to the filtered extracts and analyzed using an IBM IR/42 Fourier transform infrared spectrometer.

Total organic carbon (TOC). *BPNL.* TOC was determined using a DC-80 total carbon analyzer equipped with a sludge and sediment sampler accessory.

Analysis of tissues

Organotins. *BPNL.* Butyltins were extracted from tissues and analyzed as for sediments.

PAHs. *BPNL.* Samples were extracted with dichloromethane using a roller under ambient conditions following SOP MSL-M-42. Samples were then cleaned using silica/alumina (5% deactivated) chromatography followed by high performance liquid chromatography cleanup (Krahn et al. 1988). Tissue extracts were analyzed for PAH compounds using the same methods as for sediments.

WES/ALG. Tissue samples were prepared for PAH/PCB analysis using a modified NaOH digestion/ether extraction method (Warner 1976). Tissue analyses were performed on whole organisms. The tissue digests were extracted by shaking in ether followed by centrifugation. Extracts were cleaned up using silica gel columns (Warner 1976). Following cleanup, the samples were concentrated to less than 1.0 ml for PAH analysis in a Zymark Turbovap™ under N_2 and analyzed using the same methods as for sediments.

Pesticides and PCBs. *BPNL.* Tissues were extracted, cleaned up, and analyzed as for sediments.

WES/ALG. For PCB analysis, tissues were extracted and cleaned up as for PAH. Following cleanup, the samples were concentrated to less than 10.0 ml for PCB analysis in a Zymark Turbovap™ under N_2. Tissue samples were prepared for pesticide analysis according to USEPA 600/4-81-055 (USEPA 1981). Whole organisms were homogenized/extracted by polytron with a 1:1 mixture of acetone:hexane. Tissue extracts were cleaned up and analyzed as for sediments.

Metals. *BPNL.* Samples were freeze-dried and blended in a Spex mixer-mill™. Approximately 5 g of mixed sample was ground in a ceramic ball mill. For Zeeman GFAA spectrometry and CVAA spectroscopy analyses, 0.2 to 0.5 g aliquots of dried homogeneous sample were digested using a mixture of nitric/perchloric acids. Three metals were analyzed: Cr, Cd, and Hg. Cd and Cr were analyzed using GFAA following the method of Bloom and Crecelius (1987). Hg was analyzed using CVAA according to the method of Bloom and Crecelius (1983).

WES/ALG. Eight metals, Ag, As, Cd, Cr, Cu, Pb, Ni, and Se, were prepared and analyzed according to USEPA Method 3050 (SW-846, 1986). Samples for Hg were prepared according to USEPA Method 7471 (SW-846, 1986). The samples were first analyzed by inductively coupled plasma (ICP) or direct coupled plasma (DCP) spectrometry, and if nothing was detected, the samples were then analyzed by graphite furnace to achieve a lower detection limit. The USEPA Methods used for analysis were: (1) USEPA Method 6010 (SW-846, 1986) for Ag, As, Cd, Cu, and Ni by ICP on a Zeeman ICAP PS 3; (2) USEPA Method 6010 (SW-846, 1986) for Ag, Cd, Cr, Cu, Pb, and Ni by DCP on an ARL Fisions DC - SS7; (3) USEPA Method 7471 for Hg using CVAA spectroscopy on a Perkin Elmer 5000. A Zeeman 500 graphite furnace was used according to the USEPA Method (SW-846, 1986) listed in parentheses for the following metals: As (7131), Cd (7191), Pb (7421), Se (7740), and Cr (7191).

Lipids. *BPNL.* Lipids were determined by drying a portion of the extract obtained from the organic extraction as described above for PCBs/PAHs, prior to any cleanup steps. The weight of the residue left after air drying was reported as the "lipid" fraction or "total extractable organics."

WES/ACT. Tissues for lipid analysis were prepared separately. Two to five grams of whole organisms were homogenized by Polytron in 20 ml 1:1 acetone:hexane (3X), and the extracts were pooled. Percent lipid content was determined gravimetrically. A 100 μl aliquot of the pooled extracts was air dried on a tared pan and weighed on a Cahn microbalance.

Statistical Methods

Sediment chemistry data and tissue bioaccumulation data were summarized using means and standard errors. Data were compared among sediments, species, or treatments using Fisher's Least Significant Difference (LSD) test, Dunnett's test, two-sample *t*-tests, or corresponding nonparametric tests (data converted to rankits). Prior to each comparison, the normality assumption was tested using the Shapiro-Wilk's test, and the equality of variances assumption was tested using Levene's test or the F' test. Where appropriate, a $\log_{10}$ transformation was applied to the data to establish normality or equalize variances. Tests were chosen to maximize power while preserving simplicity, and to conform as much as possible with the statistical testing sequences in the revised Inland Testing Manual (USEPA/USACE 1994, Appendix D).[1] Means, standard errors, statistical tests used, and the results of comparisons are tabulated in Appendix A. All data analyses were conducted using PC/SAS® (SAS Institute Inc. 1988a,b).

Statistical procedures used to evaluate the experimental data and provide answers to the OHDP study objective questions are described as follows:

Objectives 1 and 2. Null hypothesis: Contaminant concentrations in the OHDP Inner, Outer, Hot, and Berkeley Flats Reference sediments do not differ significantly from each other. Statistical tests: LSD or *t*-tests on untransformed data, log-transformed data, or rankits, as shown in Figure 6.

[1] Dunnett's test, which is inappropriate for the usual comparisons of the dredged material disposal Tiered Testing approach, is not included in the Inland Testing Manual.

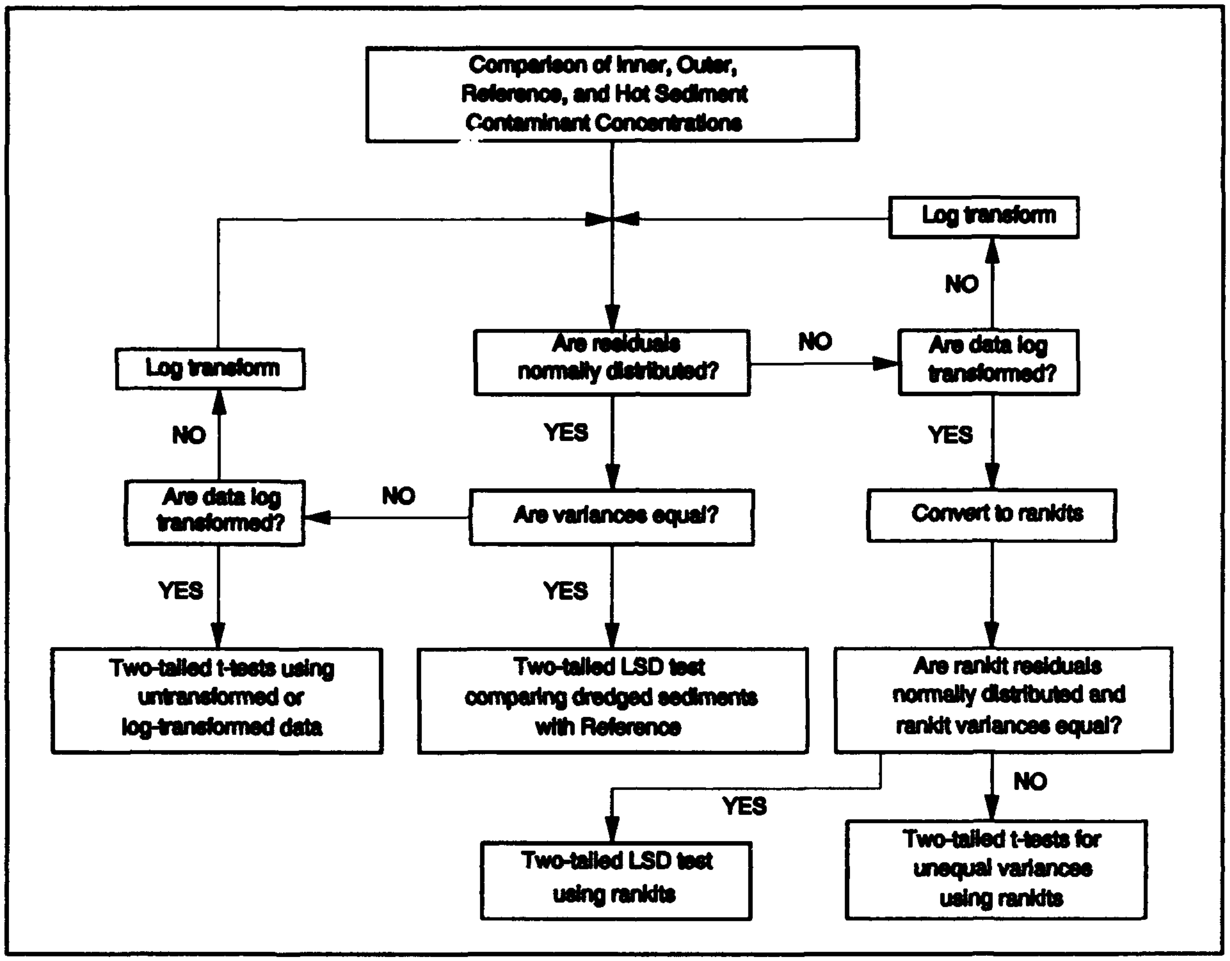

Figure 6. Decision tree for statistical procedures used in comparison of sediments

Objective 3. Null hypothesis: Background contaminant tissue concentrations (taken at Day 0 of each experiment) do not differ significantly from those at the end of each experiment (Day 28) for each treatment (BS, S50, and PC) in each species. Statistical tests: Dunnett's test or α-adjusted t-tests on untransformed data, log-transformed data, or rankits (Figure 7). The α-adjusted t-tests, in which the significance level α is divided by the number of comparisons performed, result in a more stringent significance level and thus increase protection against falsely rejecting the null hypothesis when several comparisons are performed.

Objective 4. Null hypothesis: Bioaccumulation of each contaminant after 28-day laboratory exposure in each experiment does not differ significantly in the three test species (mussels, clams, and fish) from all treatments combined. Statistical tests: LSD or α-adjusted t-tests on untransformed data, log-transformed data, or rankits (Figure 8). Prior to the LSD tests, a randomized blocks analysis of variance (ANOVA) was performed, with the treatments (BS, S50, and PC) as blocks. Differences determined by the LSD were considered significant only if the ANOVA F for species was significant.

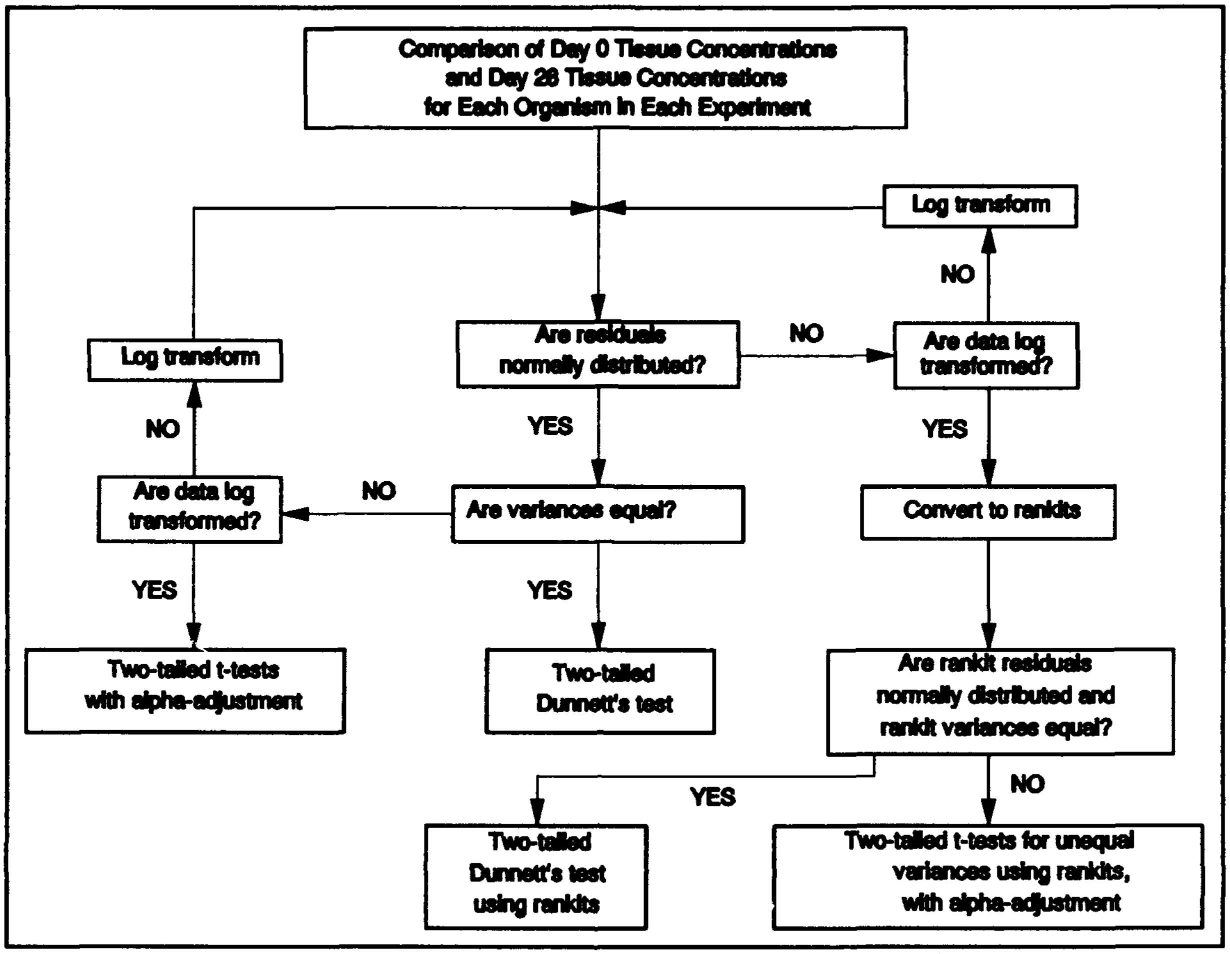

Figure 7. Decision tree for statistical procedures used in comparing Day 28 bioaccumulation with background (Day 0) tissue concentrations

Objective 5. Null hypothesis: For each experiment, bioaccumulation of each contaminant does not differ significantly between the BS treatment and the S50 treatment in each of the three species and in all three species combined. Statistical tests: *t*-test for equal or unequal variances on untransformed or log-transformed data, or Wilcoxon Rank-Sum test (Figure 9).

Objective 6a,b. Null hypothesis: In each species, contaminant bioaccumulation does not differ significantly among the four sediments following 28-day exposures. Statistical tests: LSD or *t*-tests on untransformed data, log-transformed data, or rankits (Figure 10). Prior to the LSD tests, a randomized blocks ANOVA was performed, with the sediment-exposure treatments (BS and S50) as blocks.

Statistical significance

A significance level $\alpha = 0.05$ was used for one-tailed comparisons, and $\alpha/2 = 0.025$ for two-tailed comparisons. Significance levels for tests of assumptions are given in Table 2. Higher values of α were used with small sample size (number of replicates), or when the design was severely unbal-

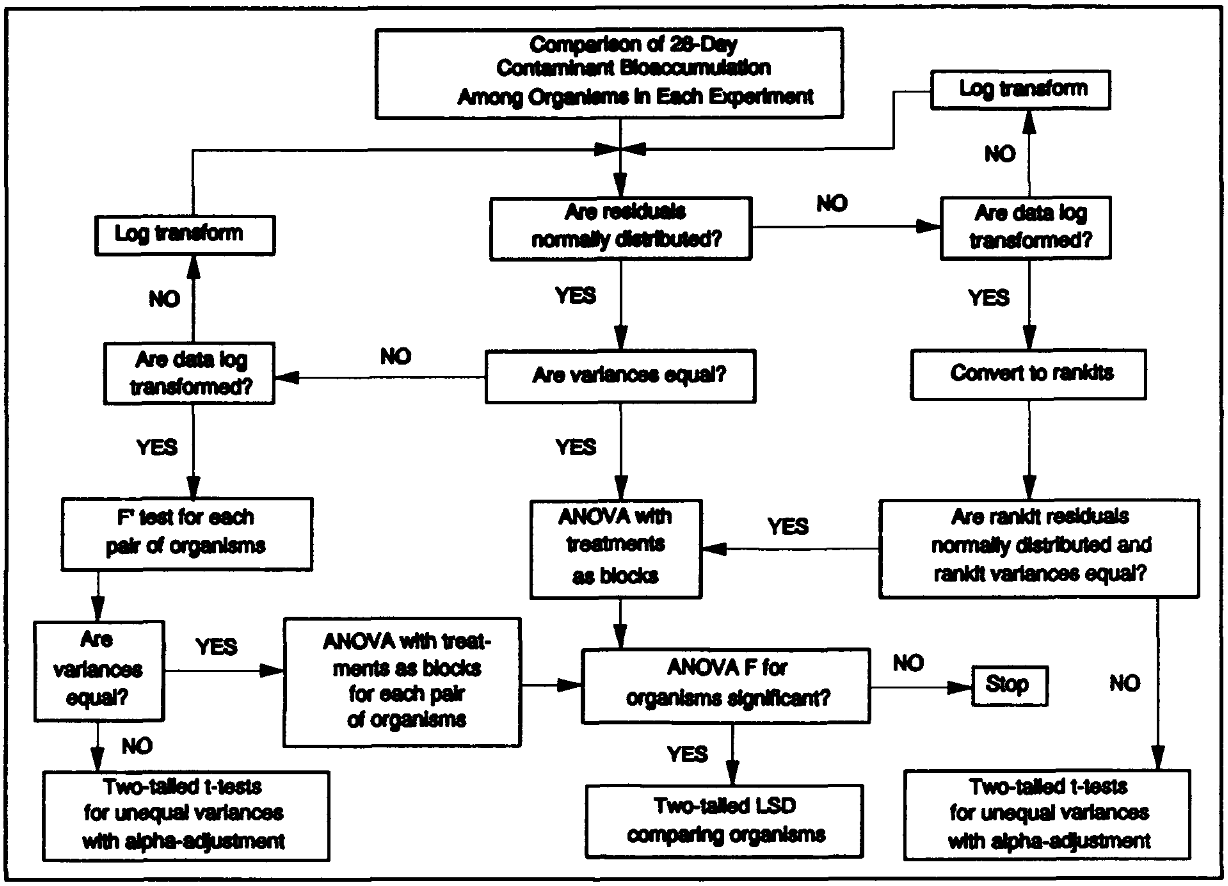

Figure 8. Decision tree for statistical procedures used in comparison of Day 28 bioaccumulation among organisms

anced (i.e., the largest sample size was at least twice the smallest sample size). These are the situations in which violations of the assumptions are most likely to compromise the validity of hypothesis testing procedures. Using higher significance levels in the tests of assumptions increases the power of these tests to detect violations of the assumptions.

Statistical power

Results of null hypothesis tests are reported in Appendix A along with the least significant difference (d_{min}) of an LSD test (or Dunnett's test) on untransformed data (regardless of which tests were actually performed). D_{min} is the magnitude of difference from the true population mean that can be detected 50 percent of the time, and is a relative indication of statistical power. A statistical test has high power when it is able to detect true significant differences a large percentage of the time. Given similar means, a test with a small d_{min} has more power than a test with a large d_{min}. D_{min} for an LSD test comparing two treatments is the same as d_{min} for a 2-sample t-test.

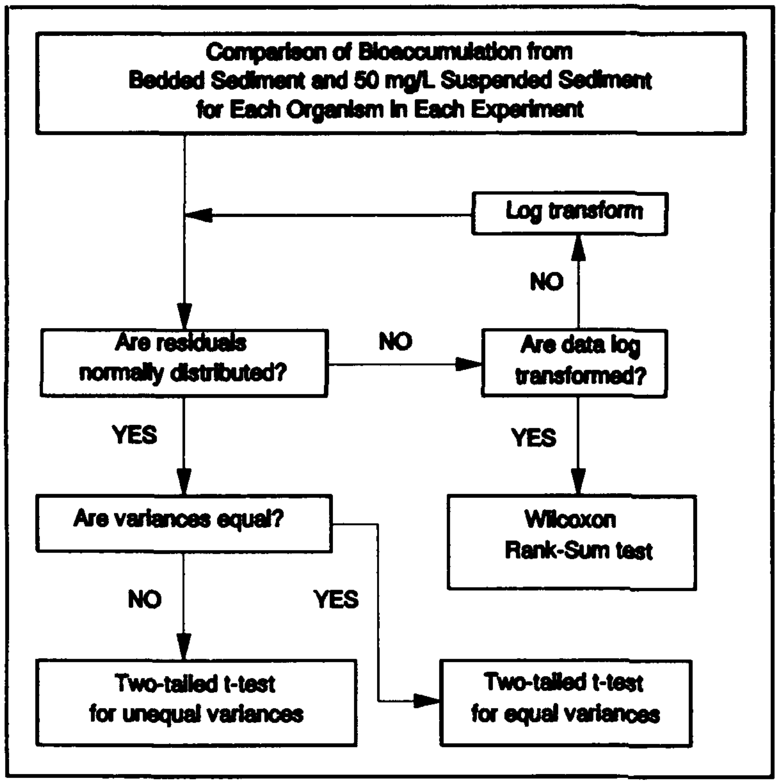

Figure 9. Decision tree for statistical procedures used in comparison of Day 28 bioaccumulation from bedded sediment (BS) and from 50 mg/L suspended sediment (S50) exposures

Data below detection limit (DL)

Much of the sediment pesticide data, and tissue bioaccumulation data for PAHs, PCBs, organotins, and pesticides, were reported as less than DL. When observations $<$DL were reported as actual quantitated values and they were within a factor of 10 of the DL, those values were used in the same way as data above DL. All other values $<$DL were set equal to DL/10 for inclusion in the statistical analyses. Statistical comparisons were not conducted when all data for those comparisons were $\leq$DL. When all data for a given treatment were $<$DL, that treatment was not considered significantly greater than any other treatment with which it was compared, regardless of the outcome of the statistical comparison procedure.

Data near DL can be greatly influenced by random variability or instrument "noise." These data are inherently less reliable than values quantitated well above the DL. It is important to remember that statistical comparisons performed on data that are mostly near or below DL can result in statistical significance that has little or no biological significance.

Surrogate recoveries

Data were considered acceptable for statistical analysis when surrogate percent recovery was within two standard deviations of the mean percent recovery for that surrogate, or when laboratory-specified quality control criteria were not exceeded.

Laboratory duplicates

A number of samples were split into duplicates (sometimes triplicates) as a laboratory quality control check. When the relative percent difference between laboratory duplicates was within the acceptable quality control criteria range, the mean of the duplicate values was used in the statistical analyses. If the relative percent difference was outside the acceptable quality control criteria range, then the mean of the duplicates was used if both duplicate values fell within the range of values for

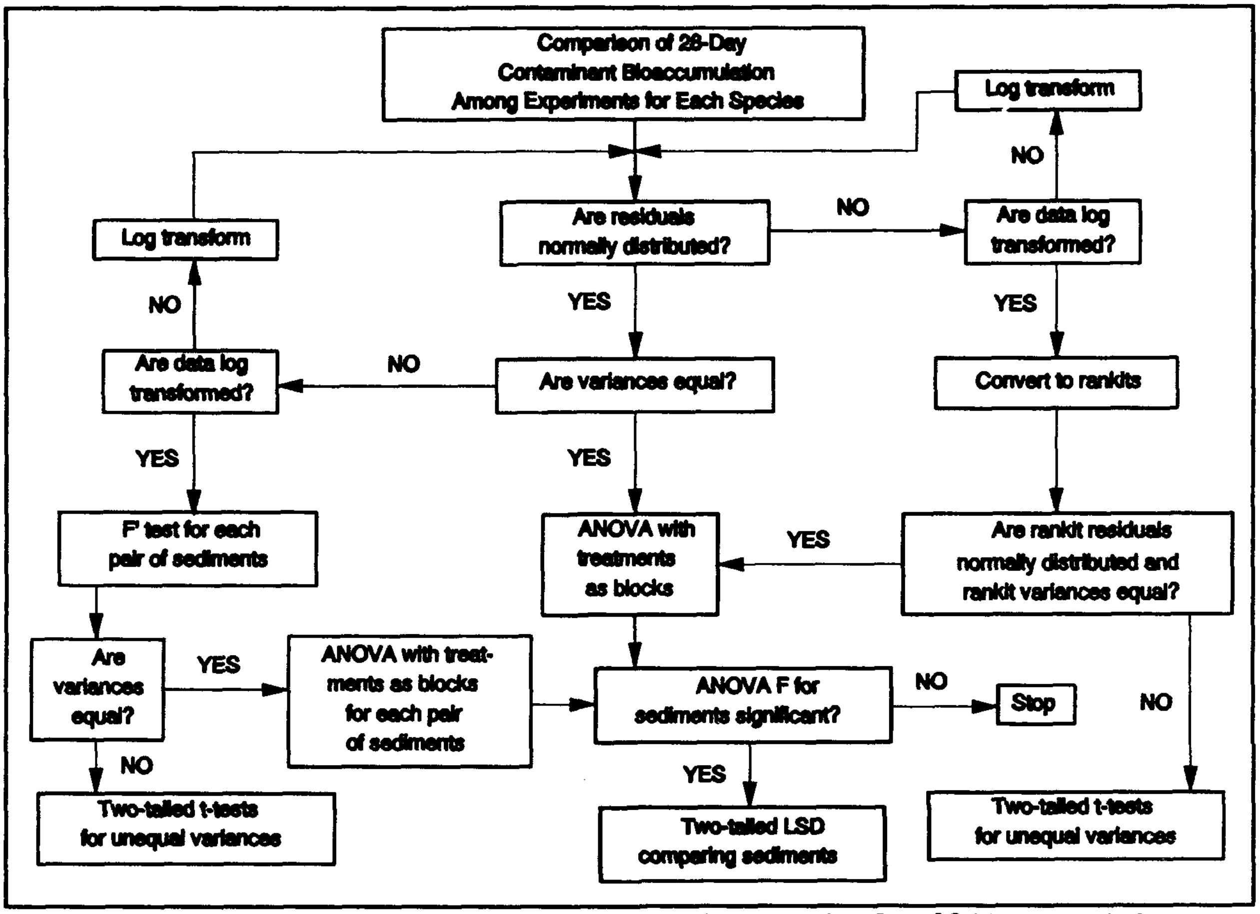

Figure 10. Decision tree for statistical procedures used in comparing Day 28 bioaccumulation among experiments

other replicates of the same treatment. Otherwise, the duplicate value was used that was within or closest to the range of values for other replicates of the same treatment.

Contaminants in blanks

When data were flagged by the analytical laboratory because the contaminant analyte was present in a blank, those data were considered biased and were not included in the statistical analyses.

Outliers

Outliers occurred frequently, especially in the PCB congener data. In general, an outlier was not deleted unless it was an obvious error, even though outliers can have adverse consequences for statistical analysis. When outliers are present, a data set may fail the normality assumption even after transformation or conversion to rankits. The mean and standard error are particularly sensitive to outliers, and may be grossly inflated when outliers are present. In this situation, the geometric mean

or the median are often better indicators of central tendency, and a statistical test comparing geometric means (i.e., log transformation) or medians (i.e., conversion to ranks or rankits) will often produce a much different, but more meaningful, outcome than a test comparing means. Readers may occasionally note this seeming paradox in the tables of Appendix A, as space permits only the tabulation of means, and not medians or geometric means.

Table 2
Alpha (α) Levels for Tests of Assumptions (from USEPA/USACE 1994, Appendix D)

Test	Number of Observations[1]	α When Design Is	
		Balanced	Unbalanced[2]
Normality	N = 3 to 9	0.10	0.25
	N = 10 to 19	0.05	0.10
	N = 20 or more	0.01	0.05
Equality of Variances	n = 2 to 9	0.10	0.25
	n = 10 or more	0.05	0.10

[1] N = total number of observations (replicates) in all treatments combined;
n = number of observations (replicates) in an individual treatment.
[2] $n_{max} \geq 2n_{min}$.

4 Results

FATES System Performance

Data generated for the major performance parameters are shown graphically in Figures 11-13 for the four experiments. Temperature was maintained at 15 ± .75°C (Figure 11) and dissolved oxygen remained high, greater than 7.5 mg/L (Figure 12). The graphed data are daily means for the 24 aquaria. Vertical bars are ± one standard error (SE). Measurements of pH made by the automated system indicated that pH remained stable (8.77 ± .05) over all experiments.

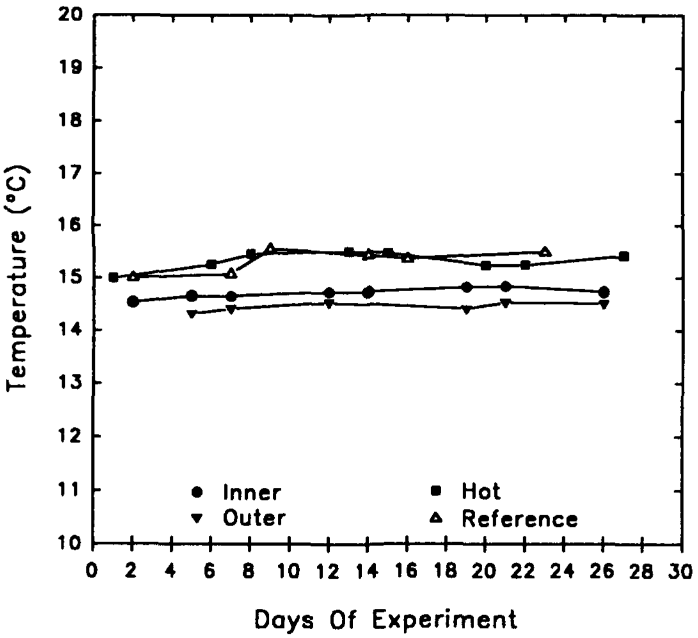

Figure 11. Mean (±SE) temperature values during FATES experiments

Total suspended solids (TSS) concentrations are shown in Figure 13. The TSS for the OHDP Inner experiment had the highest variability. The low (S10) and high (S50) suspended sediment concentrations over the course of the OHDP Inner experiment averaged near 35 and 70 mg/L, respectively. Suspended sediment concentrations in the OHDP Outer and Hot, and the Berkeley Flats Reference experiments were nearer the target concentrations of 10 and 50 mg/L, averaging ≈ 20 and 60 mg/L.

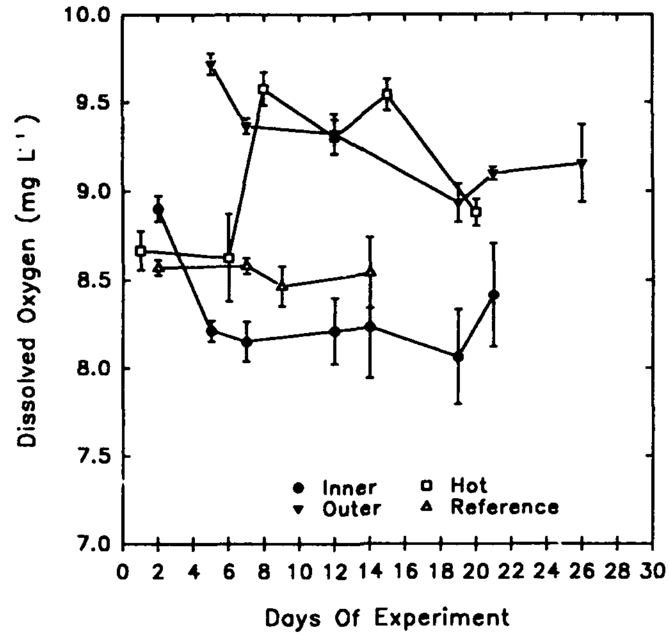

Figure 12. Mean (±SE) dissolved oxygen values for FATES experiments

Comparison of Sediments

Contaminant concentrations in the sediments (Inner, Outer, Hot, and Reference) were compared (Appendix A, Tables A1 to A4). Although all sediments were compared with each other in the statistical tests, the main comparisons of interest were Inner, Outer, and Hot with Reference, as well as Inner and Outer with Hot. The expectation was that contaminant concentrations would be highest in Hot and lowest in Reference. In general, contaminant concentrations were higher, sometimes much higher, in Hot than in the other sediments. However, the Inner sediment, which was predominantly sand, tended to have the lowest contaminant concentrations. Reference contaminant concentrations were often comparable with those of Outer, and were intermediate between Inner and Hot.

Based on the analytical chemistry results, the primary contaminants of concern in these sediments and in the four experiments to be discussed below include 15 PAHs; the metals Cd, Cr, and Hg; tributyltin (TBT) and dibutyltin (DBT); and the PCB mixture Aroclor 1254. Tables included in the Results section and the figures of Appendix B summarize statistical comparisons for these primary contaminants of concern. Other contaminants analyzed are discussed in the text when appropriate, and are included in the tables of Appendix A. Sediment comparisons for the primary contaminants of concern are summarized in Table 3 and illustrated in Figures B1 to B11.

PAHs were present in relatively high concentrations in the Hot sediment; mean concentrations of all 15 PAHs were significantly higher in Hot (by one to three orders of magnitude) than in the other sediments (Table A1, Figures B1 to B8). The typical ordering of PAH concentrations in the sediments was Hot > (Reference, Outer) > Inner, with generally comparable mean concentrations in Reference and Outer. Only acenaphthene, dibenz[a,h]anthracene, and fluorene were significantly

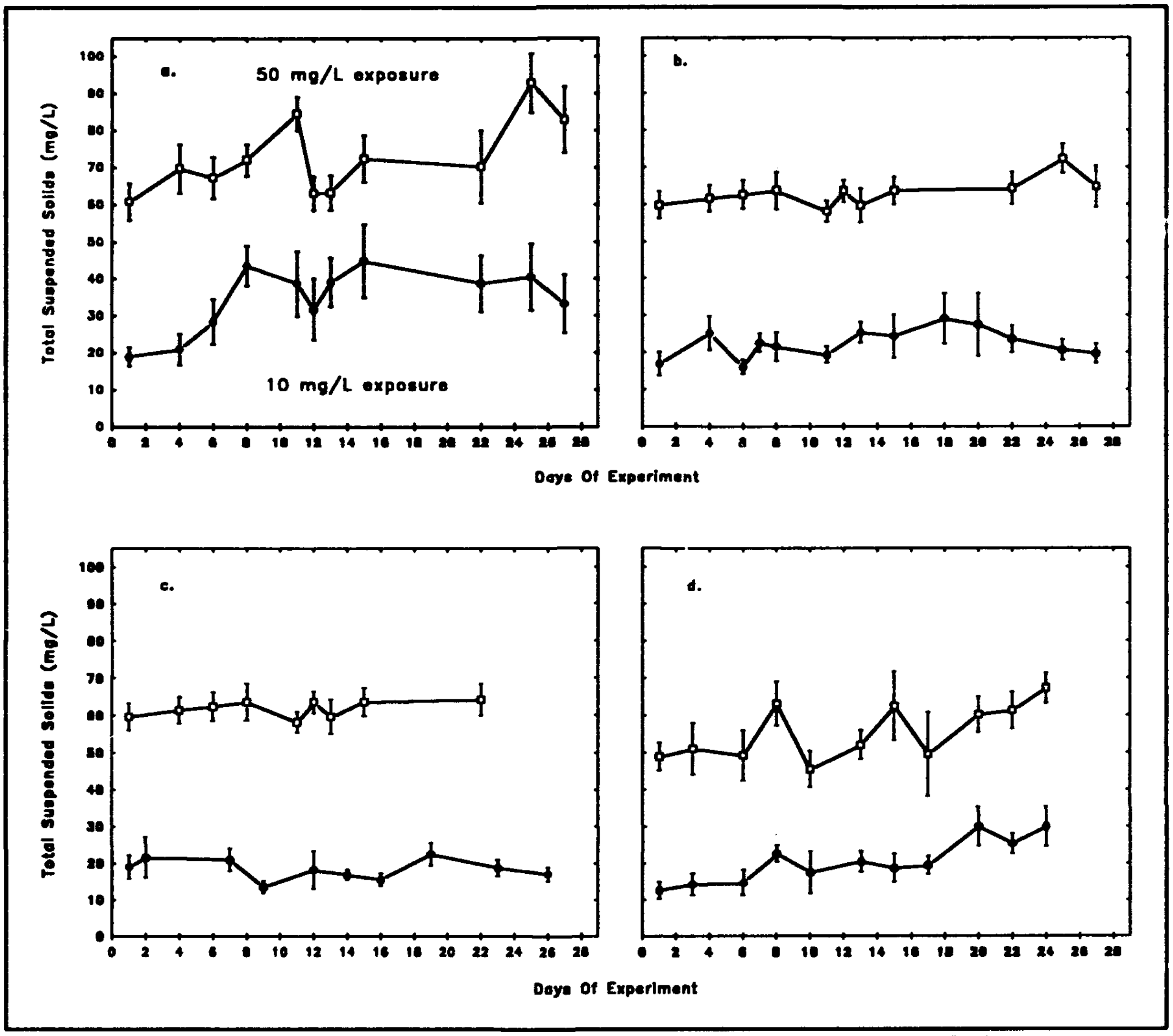

Figure 13. Mean (±SE) total suspended solids measurements for S50 (□) and S10 (●) exposures in FATES experiments. a. Inner b. Outer c. Hot d. Reference

higher in the Outer sediment than in Reference (Figures B1, B5, B6). Mean PAH concentrations in the Inner sediment were lower than in Reference in most cases; none was significantly greater than Reference (Table 3).

Among the metals, the typical PAH contamination pattern of Hot > (Reference, Outer) > Inner was seen for Ag, Cd, Cu, Ni, Pb, and Zn (Table A2). Cd is shown in Figure B9. Arsenic was significantly higher in Reference than in Inner, with Outer and Hot intermediate in mean concentration. Cr was highest in Inner, followed by Hot, followed by Outer, with the lowest mean concentration in Reference (Figure B9). The pattern for Hg was Outer > Reference > Inner > Hot (Figure B9). Se was significantly higher in Outer than in Hot and Reference, with intermediate mean concentration in Inner.

Table 3
Summary of Significant Comparisons Among Sediments for Primary Contaminants of Concern

Contaminant	Significant Statistical Comparison	
	Comparisons with Reference	Comparisons with Hot
Acenaphthene	Hot, Outer > Reference	Hot > Outer, Inner, Reference
Acenaphthylene	Hot > Reference > Inner	Hot > Outer, Reference, Inner
Anthracene	Hot > Reference > Inner	Hot > Outer, Reference, Inner
Benz[a]anthracene	Hot > Reference > Outer, Inner	Hot > Reference, Outer, Inner
Benzo[a]pyrene	Hot > Reference > Outer, Inner	Hot > Reference, Outer, Inner
Benzo[b+k]fluoranthene	Hot > Reference > Inner	Hot > Reference, Outer, Inner
Benzo[g,h,i]perylene	Hot > Reference > Inner	Hot > Outer, Reference, Inner
Chrysene	Hot > Reference > Outer, Inner	Hot > Reference, Outer, Inner
Dibenz[a,h]anthracene	Hot, Outer > Reference	Hot > Outer, Inner, Reference
Fluoranthene	Hot > Reference > Outer, Inner	Hot > Reference, Outer, Inner
Fluorene	Hot, Outer > Reference	Hot > Outer, Inner, Reference
Indeno[1,2,3-cd]pyrene	Hot > Reference > Inner	Hot > Reference, Outer, Inner
Naphthalene	not significant	Hot > Outer, Inner
Phenanthrene	Hot > Reference > Outer, Inner	Hot > Reference, Outer, Inner
Pyrene	Hot > Reference > Inner	Hot > Reference, Outer, Inner
Cd	Hot, Outer > Reference > Inner	Hot > Outer, Reference, Inner
Cr	Inner, Hot, Outer > Reference	Inner > Hot > Outer, Reference
Hg	Outer > Reference > Inner, Hot	Outer, Reference, Inner > Hot
TBT	Hot > Reference	Hot > Inner, Reference, Outer
DBT	Inner > Reference	not significant
Aroclor 1254	Hot, Outer > Reference	Hot > Outer, Reference, Inner

Pesticides were generally undetected or present at low levels in the sediments; several were < DL in all sediments (β-BHC, δ-BHC, chlordane, endosulfan sulfate, endrin, endrin ketone, methoxychlor, heptachlor, and toxaphene). All mean pesticide concentrations were < 10 ng/g dry weight (Table A3) in all sediments. Pesticide concentrations tended to be higher in Hot and/or Reference than in the other sediments, but there was no particular ordering of pesticide concentrations among the sediments as with the PAHs. DDT, for example, was significantly higher in Reference than in Hot (Figure B10), while endrin aldehyde and heptachlor epoxide did not differ significantly among any of the sediments.

PCBs were analyzed as Aroclors 1221, 1232, 1242, 1248, 1254, and 1260; only Aroclor 1254 was detected in the sediments. Aroclor 1254 concentrations were significantly higher in Hot than in Outer, and in Outer than in Reference and Inner (Table A3, Figure B10). The organotin (Table A3) tetrabutyltin (TeBT) did not differ significantly among the sediments. TBT was highest in Hot and lowest in Outer (Figure B11), DBT was highest in Hot and lowest in Reference although only Inner was significantly greater than Reference (Figure B11), while monobutyltin (MBT) was highest in Hot and lowest in Reference and Inner.

Sediment conventional parameters (oil and grease, total petroleum hydrocarbons, moisture, TOC, total volatile solids, and percent gravel, sand, silt, and clay) are reported in Table A4. Oil and grease and total petroleum hydrocarbon concentrations were compared statistically among the sediments. Both followed the same pattern of sediment contamination as the PAHs: Hot > (Outer, Reference) > Inner. All sediments were low in TOC, ranging from about 0.2 to 1 percent, the lowest being Inner, which was predominantly sand. Outer and Hot were sandy clay with a fair amount of silt, while Reference was silty clay with very little sand.

Bioaccumulation Comparisons

Bioaccumulation results from the four Oakland experiments (Inner, Outer, Reference, and Hot) necessitate statistical comparisons involving three species, several treatments, and numerous contaminants. Because of the large number of permutations, only those comparisons for the contaminants of concern in each sediment are summarized in the tables that follow (Tables 4-10). Readers wishing to see the general trends in bioaccumulation from each sediment should refer to these tables. More complete information is provided in the text descriptions of the following sections, the tables of Appendix A, and the figures of Appendix B.

Oakland Inner experiment

PAHs, metals, and organotins were analyzed for bioaccumulation from the OHDP Inner sediment. Of the 16 PAHs analyzed, only three (phenanthrene, fluoranthene, and pyrene) were reported in tissue samples but all reported values were < DL. Only pyrene had concentrations > DL/10; of these four observations, three occurred in fish and one in clams. Because all tissue PAH concentrations were < DL, statistical comparisons were not performed. TBT, DBT, and the metals bioaccumulated to detectable levels. Statistical comparisons for the primary contaminants of concern are summarized in Table 4.

Table 4
Summary of Significant Statistical Comparisons for Bioaccumulation of Primary Contaminants of Concern in OHDP Inner Experiment

Contaminant	Statistical Comparison		
	Day 0 vs. Day 28	Organisms	BS vs. S50
PAHs	All < Detection Limit		
Cd	NS[1]	Mussel > clam, fish	NS
Cr	BS > Day 0 (M,C,F)[2] S50 > Day 0 (M,C)	Clam > mussel, fish	BS > S50 (C,F,A)
Hg	NS	Fish > mussel, clam	NS
TBT	BS > Day 0 (C)	Clam > mussel, fish	NS
DBT	NS	Mussel > clam > fish	NS
Aroclor 1254	Not Analyzed		

[1] NS = No significant differences detected in the statistical analysis.
[2] M = Mussel, C = clam, F = fish, A = all organisms combined.

Comparison of Day 0 (background) vs. Day 28 (exposure) bioaccumulation. Statistical comparisons were performed for metals, organotins, and lipid (Table A5). Factoral bioaccumulation, expressed as $\log_{10}$([exposure]/[background]), is shown in Figure B12 for Cd, Cr, and Hg from the BS and S50 treatments. Cd, Hg, and DBT Day 28 bioaccumulation did not differ from Day 0 concentrations (Table 4). Cr bioaccumulation from BS was significantly higher than Day 0 concentrations in all three species, while Cr bioaccumulation from S50 was significantly higher than Day 0 concentrations in mussels and clams. TBT bioaccumulation from BS was significantly higher than Day 0 concentrations in clams. Lipid content at Day 0 was significantly higher than at Day 28 for mussels exposed to S50; clams exposed to BS and PC; and fish exposed to BS, PC, and S50.

Comparison of organisms. Bioaccumulation of TBT, DBT, and metals after 28 days from all exposures combined was compared among the three organisms used in the experiment (Table 4, Figures B13 to B17). Descriptive statistics and the results of the statistical comparisons are reported in Table A6. The three species exhibited no consistent patterns of contaminant uptake relative to each other. Clams bioaccumulated the most As, Cr (Figure B14), Pb, Ni, and TBT (Figure B16); mussels bioaccumulated the most Cd (Figure B13) and DBT (Figure B17); while fish bioaccumulated the most Hg (Figure B15). With the exception of Hg and Cr, the lowest mean concentrations of the metals and organotins occurred in the fish. Lipid content was significantly higher in mussels than in clams or fish.

Comparison of bioaccumulation from bedded vs. suspended sediment. Bioaccumulation of Cd, Cr, Hg, TBT, and DBT in each organism and in all three species combined was compared following 28-day exposures to either BS or S50 (Table 4, Figures B18 to B22). The other metals were not

analyzed from BS exposures. Descriptive statistics and the results of the statistical comparisons are reported in Table A7. Contaminant bioaccumulation from BS did not differ significantly from bioaccumulation from S50, with one exception: clams, fish, and all organisms combined accumulated significantly more Cr from BS than from S50 (Figure B19). Lipid content was significantly higher in mussels exposed to BS than in mussels exposed to S50. Differences in lipid content between the two treatments were not significant for clams, fish, or all organisms combined.

Oakland Outer experiment

PAHs, Cd, Cr, Hg, and PCB Aroclors and congeners were analyzed for bioaccumulation from the OHDP Outer sediment. Of the 16 PAHs analyzed, four (phenanthrene, fluoranthene, pyrene, and benz[a]anthracene) were reported in tissue samples but all reported values were <DL. Only pyrene had reported values >DL/10; of these two values, one occurred in mussels and one in clams. Because all tissue PAH concentrations were <DL, statistical comparisons were not performed. The metals bioaccumulated to detectable levels. Some of the PCBs (Aroclor 1254, total PCB, and congeners 15, 52, 137, 156, 171, 194, 196, 203, and 209) bioaccumulated to concentrations >DL. Statistical comparisons for the primary contaminants of concern are summarized in Table 5.

Table 5
Summary of Significant Statistical Comparisons for Bioaccumulation of Primary Contaminants of Concern in OHDP Outer Experiment

Contaminant	Statistical Comparison		
	Day 0 vs. Day 28	Organisms	BS vs. S50
PAHs	All < Detection Limit		
Cd	BS > Day 0 (M)[1] S50 > Day 0 (M) PC > Day 0 (M,C)	Mussel > fish > clam	NS[2]
Cr	BS > Day 0 (M) S50 > Day 0 (M,C)	Clam > mussel > fish	NS
Hg	Day 0 > BS (M) Day 0 > S50 (M,C)	Mussel > fish > clam	NS
TBT	Not Analyzed		
DBT	Not Analyzed		
Aroclor 1254	NS	Fish, mussel > clam[3]	S50 > BS (M)

[1] M = Mussel, C = clam, F = fish, A = all organisms combined.
[2] NS = No significant differences detected in the statistical analysis.
[3] No significant differences among organisms with outlier deleted and all values < DL set = mean DL/10.

Comparison of Day 0 (background) vs. Day 28 (exposure) bioaccumulation. Bioaccumulation of Aroclors 1242 and 1254, total PCB, and congeners 15, 52, and 60 after 28 days did not differ significantly from Day 0 concentrations in clams (Table A8). Day 0 samples from mussels and fish were not analyzed for PCBs. Factoral bioaccumulation, expressed as $\log_{10}$([exposure]/[background]), is shown in Figure B23 for Cd, Cr, and Hg from the BS and S50 treatments. Mussels exposed to BS, S50, and PC, and clams exposed to PC bioaccumulated significantly more Cd than Day 0 concentrations (Table 5). Mussels exposed to BS and S50, and clams exposed to S50 bioaccumulated significantly more Cr than Day 0 concentrations. On the other hand, Day 0 Hg concentrations were significantly higher than Day 28 bioaccumulation from BS (mussels) and from S50 (mussels and clams). Bioaccumulation of Cr and Hg from PC was not analyzed. Lipid content of both mussels and fish was significantly greater at Day 0 than at Day 28 regardless of treatment. Lipid content of clams did not differ significantly from Day 0 to Day 28.

Comparison of organisms. Bioaccumulation of the PCBs detected in tissue samples after 28 days from all exposures combined was compared among the three organisms used in the experiment. Descriptive statistics and the results of the statistical comparisons are reported in Table A9. Fish bioaccumulated significantly more PCBs than clams with the exception of congener 209. Fish bioaccumulated significantly more total PCB and congeners 52[1], 137, 156, 171, 194, 196, and 203 than did mussels. It should be noted, however, that the latter six congeners each had only one value >DL, a relatively high concentration in a fish positive control. If this replicate is considered an outlier and deleted, then only Aroclor 1254, total PCB, and congeners 15, 52, and 209 bioaccumulated to levels >DL. Descriptive statistics and statistical comparisons for these PCBs with the outlier replicate removed are also reported in Table A9. Also included is an analysis of the detection limits; it is interesting to note that if all replicates are analyzed as DL/10; the mean DL/10 for fish is significantly greater than the mean DL/10 for mussels and clams. Consequently, the significant differences noted in PCB concentrations among the organisms may be merely an artifact of differences in the DLs. This is a shortcoming of the method of substituting DL or a fraction of the DL for <DL observations. To eliminate the effect of differences in DL, the analyses for Aroclor 1254, total PCB, and congeners 15, 52, and 209 (with the outlier deleted) were rerun, setting all values that were <DL/10 for a given contaminant equal to the mean DL/10 for that contaminant. Concentrations of total PCB and congener 52 remained significantly higher in fish than in clams, but the difference became nonsignificant for Aroclor 1254 (Figure B24) and congener 15 (Table A9).

The bioaccumulation pattern for Cd (Figure B13) and Hg (Figure B15) was mussels > fish > clams, while the pattern for Cr (Figure B14) was clams > mussels > fish (Tables 5, A9). Lipid content did not differ significantly among organisms.

Comparison of bioaccumulation from bedded vs. suspended sediment. Bioaccumulation of Aroclor 1254 (Figure B25), total PCB, congeners 15, 52, and 209; Cd, Cr, and Hg (Figures B18 to B20); and lipid content in each organism and in all three species combined was compared following 28-day exposures to either BS or S50. Descriptive statistics and the results of the statistical comparisons are reported in Table A10. Mussels accumulated significantly more Aroclor 1254 (Table 5, Figure B25) and total PCB from S50 than from BS. PCB congener and metals bioaccumulation did not differ significantly between BS and S50 in any of the organisms. Clams exposed to S50 had significantly higher lipid content than clams exposed to BS.

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[1] Median (not mean) bioaccumulation was significantly higher in fish than in mussels as determined by nonparametric analysis.

Berkeley Flats Reference experiment

PAHs, metals, organotins, and PCBs were analyzed for bioaccumulation following exposure to Berkeley Flats Reference sediment. Pesticides were analyzed from the PC treatment only. PCBs were analyzed as Aroclors and a number of individual congeners; some PCB congeners coeluted and were reported together. All analyzed PAHs, metals, organotins, most PCBs, and some pesticides had reported concentrations in at least some of the tissue samples, although many were <DL in all tissue samples from a given organism. The following pesticides and PCBs were <DL in all samples: α-BHC, β-BHC, γ-BHC, δ-BHC, aldrin, endosulfan I and II, dieldrin, endrin aldehyde, endosulfan sulfate; Aroclors 1242, 1248, 1254, 1260, and PCB congener 107. Data for endrin were unusable due to calibration problems. Some of the data for PCB congeners 31+28, 33, 33+53, 48+47, 52, 64+41+71, and 95+66 were unusable because analyte was found in the blanks. Statistical comparisons for the primary contaminants of concern are summarized in Table 6.

Comparison of Day 0 (background) vs. Day 28 (exposure) bioaccumulation. Contaminant bioaccumulation after 28-day exposure to Reference BS, S50, and PC was compared with background tissue concentrations (Day 0) in each organism (Table A11). All contaminants for which a treatment was either significantly greater than or less than Day 0 are listed in Table 7 for each organism. Tissue concentrations after 28-day exposure to one or more of the treatments were significantly higher than background levels at Day 0 for many of the contaminants. A few contaminants had significantly lower tissue concentrations at Day 28 than at Day 0. Factoral bioaccumulation, expressed as $\log_{10}$([exposure]/[background]), is shown for the primary contaminants of concern in Figures B26 (mussels, BS), B27 (mussels, S50), B28 (clams, BS), B29 (clams, S50), B30 (fish, BS), and B31 (fish, S50). Those contaminants for which bioaccumulation was significantly greater than or less than Day 0 concentrations are indicated in the figures with an asterisk. The highest concentrations of most PCB congeners (especially the higher chlorinated ones) occurred after 28-day exposure to PC in all three organisms.

Comparison of organisms. Descriptive statistics for each contaminant in each organism after 28 days exposure to the Reference sediment, and the results of the statistical comparisons are reported in Table A12. Significant comparisons for the primary contaminants of concern are summarized in Table 6. Fish had the lowest concentrations of all PAHs (Figures B32 to B40), Cd (Figure B13), TBT (Figure B16), DBT (Figure B17), and heptachlor epoxide; concentrations of all of these contaminants except acenaphthene, acenaphthylene, and heptachlor epoxide were significantly lower in fish than in one or both mollusk species. Clams had significantly higher concentrations of benz[a]anthracene (Figure B33), benzo[a]pyrene (Figure B34), benzo[b]fluoranthene (Figure B34), benzo[g,h,i]-perylene (Figure B35), indeno[1,2,3-cd]pyrene (Figure B38), Cr (Figure B14), and MBT than mussels. Mussels had significantly higher concentrations of anthracene (Figure B33), dibenzothiophene (Figure B37), naphthalene (Figure B39), phenanthrene (Figure B39), Cd (Figure B13), TBT (Figure B16), and DBT (Figure B17) than clams. Fish had significantly higher concentrations of Hg than clams or mussels (Figure B15). Bioaccumulation of most of the pesticides did not differ significantly among the organisms, and many of the observations were <DL. However, mussels had significantly more γ-chlordane and DDD than clams or fish, and clams had significantly less DDT than mussels or fish. Lipids also were analyzed; mussels had significantly higher lipid content than fish.

Table 6
Summary of Significant Statistical Comparisons for Bioaccumulation of Primary Contaminants of Concern in Berkeley Flats Reference Experiment

Contaminant	Statistical Comparison		
	Day 0 vs. Day 28	Organisms	BS vs. S50
Acenaphthene	NS[1]	NS	NS
Acenaphthylene	PC > Day 0 (M)[2]	NS	S50 > BS (C)
Anthracene	Day 0 > PC (M)	Mussel > clam > fish	NS
Benz[a]anthracene	S50 > Day 0 (M,F)	Clam > mussel > fish	NS
Benzo[a]pyrene	BS > Day 0 (C) S50 > Day 0 (C) PC > Day 0 (M)	Clam > mussel > fish	NS
Benzo[b]fluoranthene	BS > Day 0 (C) S50 > Day 0 (C)	Clam > mussel > fish	S50 > BS (C)
Benzo[k]fluoranthene	NS	Clam, mussel > fish	NS
Benzo[g,h,i]perylene	BS > Day 0 (C) S50 > Day 0 (C) PC > Day 0 (M)	Clam > mussel, fish	NS
Chrysene	NS	Clam, mussel > fish	NS
Dibenz[a,h]anthracene	NS	Clam > fish	NS
Dibenzothiophene	NS	Mussel > clam > fish	NS
Fluoranthene	S50 > Day 0 (M) Day 0 > BS (C)	Clam, mussel > fish	S50 > BS (M,C,A)
Fluorene	Day 0 > BS (M) Day 0 > S50 (C) Day 0 > PC (M)	Clam, mussel > fish	NS
Indeno[1,2,3-cd]pyrene	BS > Day 0 (C) S50 > Day 0 (C) PC > Day 0 (F)	Clam > mussel > fish	NS
Naphthalene	Day 0 > PC (M)	Mussel > clam, fish	NS

[1] NS = No significant differences detected in the statistical analysis.
[2] M = Mussel, C = clam, F = fish, A = all organisms combined.

(Continued)

Table 6 (Concluded)			
	Statistical Comparison		
Contaminant	**Day 0 vs. Day 28**	**Organisms**	**BS vs. S50**
Phenanthrene	NS	Mussel > clam, fish	S50 > BS (M)
Pyrene	S50 > Day 0 (M) PC > Day 0 (M)	Mussel, clam > fish	S50 > BS (M,C,A)
Cd	S50 > Day 0 (M) PC > Day 0 (M,C,F)	Mussel > clam, fish	S50 > BS (M)
Cr	BS > Day 0 (M,C) S50 > Day 0 (M,C) PC > Day 0 (M)	Clam > fish > mussel	S50 > BS (F)
Hg	BS > Day 0 (C) S50 > Day 0 (C) PC > Day 0 (M)	Fish > mussel, clam	NS
TBT	BS > Day 0 (M,C,F) S50 > Day 0 (M,C,F) PC > Day 0 (M,C)	Mussel > clam > fish	NS
DBT	BS > Day 0 (M) S50 > Day 0 (M,C) PC > Day 0 (M,C)	Mussel > clam > fish	NS
Aroclor 1254	All < Detection Limit		

PCB congeners did not exhibit any consistent pattern of bioaccumulation among the three organisms (Table A12). Most congeners did not differ significantly among species. The following congeners had significantly higher concentrations in mussels than in clams and/or fish: 8+5, 18,[1] 22 and 22+51, 25, 26,[2] 27, 31+28, 40, 45, 48+47, 49 and 49+43, 52, 56+60, 63, 74, 83, 85, 84 and 92+84, 101 and 101+89, 110 and 110+77, 118 and 118+149,[3] 128, 135+144, 146, 149, 153+132+105, 157+200, 158, 170+190, 173, 177, 180, 183, and 187+182. Far fewer PCB congeners had significantly higher concentrations in clams than in mussels and/or fish: 17, 56+60, 82, 95+66, 134+114, 170+190, and 202+171. Only congeners 52, 63, and 85 were significantly higher in fish than in clams. Aroclor 1254 was <DL in all samples (Figure B19).

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[1] Median (not mean) bioaccumulation was significantly higher in mussels than in fish.

[2] Geometric mean (i.e., log-transformed) bioaccumulation was significantly higher in mussels than in fish.

[3] Median (not mean) bioaccumulation was significantly higher in mussels than in clams.

Table 7
Berkeley Flats Reference Experiment: Contaminants Significantly Greater Than or Less Than Background Concentrations (Day 0) Following 28-Day Exposures to Bedded Sediment (BS), 50 mg/L Suspended Sediment (S50), or Positive Control (PC)

Statistically Significant Comparison	Organism		
	Mussel	Clam	Fish
BS > Day 0	Cr TBT, DBT PCB congeners 18, 25, 63	Benzo[a]pyrene Benzo[b]fluoranthene Benzo[g,h,i]perylene Indeno[1,2,3-cd]pyrene Cr, Hg; TBT PCB congeners 25, 31+28, 134+114, 163+138	TBT PCB congeners 63, 141, 163+138
S50 > Day 0	Benz[a]anthracene Fluoranthene Ppyrene Cd, Cr TBT, DBT PCB congeners 25, 31+28, 63, 74, 83	Benzo[a]pyrene Benzo[b]fluoranthene Benzo[g,h,i]perylene Indeno[1,2,3-cd]pyrene Cr, Hg TBT, DBT, MBT PCB congeners 134+114	Benz[a]anthracene TBT PCB congener 82
PC > Day 0	Acenaphthylene Benzo[a]pyrene Benzo[g,h,i]perylene Fluoranthene, pyrene Cd, Cr, Hg; TBT, DBT PCB congeners 18, 19, 25, 26, 32+16, 33 and 33+53, 42+37, 49 and 49+43, 70+76, 82, 84 and 92+84, 85, 97, 101 and 101+89, 110 and 110+77, 136, 151, 158, 172+197, 177, 178, 199, 205	Cd TBT, DBT PCB congeners 22 and 22+51, 27, 49 and 49+43, 82, 135+144, 136, 201, 203+196 Lipid	Indeno[1,2,3-cd]pyrene Cd PCB congeners 22 and 22+51, 25, 45, 56+60, 91, 97, 100, 136, 153+132+105, 172+197, 187+182, 201, 203+196
Day 0 > BS	Fluorene PCB congeners 141, 146, 183	Fluoranthene PCB congeners 42+37, 52, 56+60, 74, 84 and 92+84, 170+190	PCB congeners 44, 84 and 92+84
Day 0 > S50	PCB congener 183	Fluorene PCB congeners 44, 52, 74, 84 and 92+84	--
Day 0 > PC	Anthracene Fluorene, naphthalene PCB congeners 163+138	--	--

Comparison of bioaccumulation from bedded vs. suspended sediment. In most cases, contaminant bioaccumulation from Reference BS did not differ significantly from contaminant

bioaccumulation from Reference S50 (Tables 6, A13; Figures B18 to B22, B41 to B49). A few exceptions involved significantly higher bioaccumulation from S50 than from BS. These included acenaphthylene in clams (Figure B41); benzo[b]fluoranthene in clams (Figure B43); fluoranthene in mussels, clams, and all organisms combined (Figure B46); phenanthrene in mussels (Figure B48); pyrene in mussels, clams, and all organisms combined (Figure B49); Cd in mussels (Figure B18); Cr in fish (Figure B19); and PCB 170+190 in clams. Several other PCB congeners had significantly higher bioaccumulation from BS than from S50: congeners 8+5, 25, 31+28, 40, 44, 45, 49 and 49+43, 63, 135+144, 146, and 153+132+105 in clams; congeners 134+114 and 141 in fish; and congener 63 in all organisms combined. Organism lipid contents did not differ significantly between the two treatments.

Oakland Hot experiment

PAHs, metals, organotins, and PCBs were analyzed for bioaccumulation following exposure to Hot sediment. Pesticides were analyzed from the PC treatment only. PCBs were analyzed as Aroclors and a number of individual congeners; some PCB congeners coeluted and were reported together. All analyzed PAHs, metals, organotins, some pesticides, Aroclor 1254, and most PCB congeners had reported concentrations in at least some of the tissue samples, although many were $<$DL in all tissue samples from the fish. The following pesticides and PCBs were $<$DL in all samples: α-BHC, β-BHC, γ-BHC, δ-BHC, heptachlor, aldrin, heptachlor epoxide, endosulfan I and II, dieldrin, endrin aldehyde, endosulfan sulfate; Aroclors 1242, 1248, 1260, and PCB congener 189. Data for endrin were unusable due to calibration problems. Many of the Aroclor surrogate recoveries were outside the accepted quality control criteria range, and so the quantitations of Aroclor 1254 could not be used for those samples. Some of the data for PCB congeners 31+28, 33+53, 46, 48+47, 52, 64+41+71, 95+66, 97, and 135+144 were unusable because analyte was found in the blanks. Statistical comparisons for the primary contaminants of concern are summarized in Table 8.

Comparison of Day 0 (background) vs. Day 28 (exposure) bioaccumulation. Contaminant bioaccumulation after 28 days exposure to Hot BS, S50, and PC was compared with background tissue concentrations (Day 0) in each organism (Tables 8, A14). Bioaccumulation of all of the primary contaminants was significant in one or both species of mollusks. All contaminants for which a treatment was either significantly greater than or less than Day 0 are listed in Table 9 for each organism. All of the PAHs and many PCB congeners had significantly higher tissue concentrations after 28-day exposure to one or more of the treatments than background levels at Day 0. Fewer contaminants, mostly in fish, had significantly lower tissue concentrations at Day 28 than at Day 0. Factoral bioaccumulation, expressed as $\log_{10}$([exposure]/[background]), is shown for the primary contaminants of concern in Figures B50 (mussels, BS), B51 (mussels, S50), B52 (clams, BS), B53 (clams, S50), B54 (fish, BS), and B55 (fish, S50). Those contaminants for which bioaccumulation was significantly greater than or less than Day 0 concentrations are indicated in the figures with an asterisk. The following contaminants did not differ significantly between Day 0 and any Day 28 treatment in any organism: MBT, and PCB congeners 17, 19, 29, 46, 107, 136, 174, 175, 180, 185, 191, 199, 205, and 207.

Mean tissue concentrations for many of the PCB congeners were higher following exposure to PC than to any of the other treatments. However, the statistical tests were not powerful enough to detect the difference between PC and Day 0 as significant, due to small sample sizes (one to three replicates) and large variability (Table A14).

Table 8
Summary of Significant Statistical Comparisons for Bioaccumulation of Primary Contaminants of Concern in OHDP Hot Experiment

Contaminant	Statistical Comparison		
	Day 0 vs. Day 28	*Organisms*	*BS vs. S50*
Acenaphthene	BS > Day 0 (C)[1a] S50 > Day 0 (M,C) Day 0 > PC (M)	Clam > mussel > fish	S50 > BS (M)
Acenaphthylene	BS > Day 0 (M) S50 > Day 0 (M)	Mussel > clam, fish	S50 > BS (M)
Anthracene	BS > Day 0 (M,C) S50 > Day 0 (M,C)	Clam > mussel, fish	S50 > BS (M)
Benz[a]anthracene	BS > Day 0 (M,C) S50 > Day 0 (M,C)	Clam, mussel > fish	S50 > BS (M,A)
Benzo[a]pyrene	BS > Day 0 (M,C) S50 > Day 0 (M,C)	Mussel, clam > fish	S50 > BS (M,A)
Benzo[b]fluoranthene	BS > Day 0 (M,C) S50 > Day 0 (M,C) Day 0 > PC (M)	Mussel, clam > fish	S50 > BS (M,A)
Benzo[k]fluoranthene	BS > Day 0 (C) S50 > Day 0 (M,C)	Mussel, clam > fish	S50 > BS (M,A)
Benzo[g,h,i]perylene	BS > Day 0 (C) S50 > Day 0 (M,C)	Mussel, clam > fish	S50 > BS (M,A)
Chrysene	BS > Day 0 (C) S50 > Day 0 (M,C)	Clam, mussel > fish	S50 > BS (M,A)
Dibenz[a,h]anthracene	BS > Day 0 (M,C) S50 > Day 0 (M,C)	Clam > mussel > fish	NS[2]
Dibenzothiophene	BS > Day 0 (M,C) S50 > Day 0 (M,C)	Clam > mussel > fish	S50 > BS (M)
Fluoranthene	BS > Day 0 (M,C) S50 > Day 0 (M,C)	Clam > mussel > fish	S50 > BS (M)
Fluorene	BS > Day 0 (C) S50 > Day 0 (M) Day 0 > PC (M)	Clam > mussel > fish	S50 > BS (M)
Indeno[1,2,3-cd]pyrene	BS > Day 0 (M,C) S50 > Day 0 (M,C)	Mussel, clam > fish	S50 > BS (M,A)

[1] M = Mussel, C = clam, F = fish, A = all organisms combined.
[2] NS = No significant differences detected in the statistical analysis.
[3] Fish intermediate between and not significantly different from mussel and clam.

(Continued)

Table 8 (Concluded)

Contaminant	Statistical Comparison		
	Day 0 vs. Day 28	Organisms	BS vs. S50
Naphthalene	BS > Day 0 (F) S50 > Day 0 (F) Day 0 > PC (M)	NS	S50 > BS (F)
Phenanthrene	BS > Day 0 (M,C,F) S50 > Day 0 (M,C,F) PC > Day 0 (F)	Clam > mussel > fish	S50 > BS (M)
Pyrene	BS > Day 0 (C) S50 > Day 0 (M,C)	Clam > mussel > fish	S50 > BS (M,A)
Cd	BS > Day 0 (M) S50 > Day 0 (M) PC > Day 0 (M) Day 0 > S50 (F)	Mussel > clam, fish	BS > S50 (F)
Cr	BS > Day 0 (M,C,F) S50 > Day 0 (M,C) PC > Day 0 (C)	Clam > mussel > fish	NS
Hg	BS > Day 0 (M,C,F) PC > Day 0 (C,F)	Mussel, fish > clam	NS
TBT	BS > Day 0 (M,C) S50 > Day 0 (M,C) PC > Day 0 (M)	Mussel > clam (fish)[3]	NS
DBT	BS > Day 0 (M,C) S50 > Day 0 (M,C) PC > Day 0 (M)	Mussel > clam > fish	BS > S50 (M)
Aroclor 1254	BS > Day 0 (M) S50 > Day 0 (M)	Mussel > clam (fish)[3]	S50 > BS (M, F)

Comparison of organisms. Descriptive statistics for each contaminant in each organism after 28 days exposure to Hot sediment, and the results of the statistical comparisons are reported in Table A15. Significant comparisons for the primary contaminants of concern are summarized in Table 8. Most of the major contaminants reached significantly higher concentrations in the mollusks than in the fish. Fish had the lowest concentrations of all PAHs (Figures B32 to B40) except naphthalene (Figure B39), and of Cd (Figure B13), Cr (Figure B14), TBT (Figure B16), DBT (Figure B17), and lipid; concentrations of all of these except TBT were significantly lower in fish than in one or both mollusks. Clams had significantly higher concentrations of acenaphthene (Figure B32), anthracene (Figure B33), dibenz[a,h]anthracene (Figure B36), dibenzothiophene (Figure B37), fluoranthene (Figure B37), fluorene (Figure B38), phenanthrene (Figure B39), pyrene (Figure B40), Cr (Figure B14), and lipid than mussels. Mussels had significantly higher concentrations of acenaphthylene (Figure B32), Cd (Figure B13), Hg (Figure B15), TBT (Figure B16), and DBT (Figure B17) than clams. Fish had significantly higher concentrations of Hg than clams (Figure B15). MBT was <DL in all fish and clam samples. Naphthalene concentrations did not differ significantly among the organisms (Figure B39). Pesticides were not analyzed in fish, and did not differ signifi-

cantly between mussels and clams. The minimum significant difference (d_{min} in Table A15) was unusually high for some of the PAHs due to the considerable variability among the concentration data for a given contaminant in a given organism. D_{min} was high for some of the pesticides due to high variability and small sample size (n = 2).

Aroclor 1254 bioaccumulation was significantly higher in mussels than in clams (Figure B24). PCB congeners did not exhibit any consistent pattern of bioaccumulation among the three organisms. Most congeners did not differ significantly among the organisms. The following congeners had significantly higher concentrations in mussels than in clams and/or fish: 18, 22, 25, 40, 42+37,[1] 44, 56+60, 70+76, 82, 83, 84 and 92+84, 87, 91, 99, 101 and 101+89, 107, 110 and 110+77, 118 and 118+149, 128, 131, 134+114, 136, 137+176, 149, 151, 153+132+105, 157+200, 158, 163+138, 170+190, 173, 177, 183, 187+182, 198, and 202+171. The following congeners had significantly higher concentrations in clams than in mussels and/or fish: 17, 22, 25, 44, 56+60, 70+76, 82, 101 and 101+89, 110 and 110+77, 128, 141, 149, 163+138, 170+190, 177, 187+182, 194, and 202+171. Congeners 33 and 33+53, and 141 were significantly higher in fish than in mussels; while congener 85 was significantly higher in fish than in clams.

Patterns of bioaccumulation among the organisms of the primary contaminants of concern (Table 8) were similar to those observed in the Berkeley Flats Reference Experiment (Table 6). In general, PAH bioaccumulation was much greater from Hot sediment than from Reference sediment, whereas bioaccumulation of metals and organotins was similar from Outer, Hot, and Reference sediments.

Comparison of bioaccumulation from bedded vs. suspended sediment. Bioaccumulation of all PAHs from Hot S50 was significantly higher in mussels than bioaccumulation from BS except for dibenz[a,h]anthracene and naphthalene (Tables 8, A16; Figures B41 to B49). PAH bioaccumulation in clams and fish did not differ significantly between BS and S50 with the exception of naphthalene in fish. In many cases the PAH concentrations in mussels were high enough and the difference between the two treatments great enough that the difference remained significant when data for all organisms were combined. A few contaminants bioaccumulated to a significantly greater extent from BS than from S50: Cd (fish, Figure B18), DBT (mussels, Figure B22), and MBT (all organisms combined). Pesticides were not analyzed in BS or S50 samples. Lipid content did not differ significantly between the two treatments for any of the organisms.

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[1] Median (not mean) bioaccumulation was significantly higher in mussels than in clams.

Table 9
OHDP Hot Experiment: Contaminants Significantly Greater Than or Less Than Background Concentrations (Day 0) Following 28-Day Exposures to Bedded Sediment (BS), 50 mg/L Suspended Sediment (S50), or Positive Control (PC)

Statistically Significant Comparison	Organism		
	Mussel	Clam	Fish
BS > Day 0	Acenaphthylene Anthracene Benz[a]anthracene Benzo[a]pyrene Benzo[b]fluoranthene Dibenz[a,h]anthracene Dibenzothiophene Fluoranthene Indeno[1,2,3-cd]pyrene Phenanthrene Cd, Cr, Hg TBT, DBT Aroclor 1254 PCB congeners 18, 22, 25, 32+16, 40, 44, 45, 49 and 49+43, 56+60, 63, 70+76, 74, 82, 83, 85, 87, 91, 97, 99, 101 and 101+89, 110 and 110+77, 118 and 118+149, 128, 134+114, 137+176, 149, 151, 153+132+105, 158, 163+138, 170+190, 177, 183, 187+182, 198, 202+171	Acenaphthene Anthracene Benz[a]anthracene Benzo[a]pyrene Benzo[b]fluoranthene Benzo[k]fluoranthene Benzo[g,h,i]perylene Chrysene Dibenz[a,h]anthracene Dibenzothiophene Fluoranthene Fluorene Indeno[1,2,3-cd]pyrene Phenanthrene Pyrene Cr, Hg TBT, DBT PCB congeners 8+5, 22, 25, 40, 44, 49 and 49+43, 56+60, 70+76, 74, 85, 99, 100, 101 and 101+89, 110 and 110+77, 118 and 118+149, 128, 134+114, 141, 149, 151, 163+138, 170+190, 177, 187+182, 194, 202+171	Naphthalene Phenanthrene Cr, Hg TBT PCB congeners 31+28, 49 and 49+43, 63, 74, 85, 87, 99, 101 and 101+89, 110 and 110+77, 118 and 118+149, 149, 151, 153+132+105, 163+138, 170+190
S50 > Day 0	Acenaphthene Acenaphthylene Anthracene Benz[a]anthracene Benzo[a]pyrene Benzo[b]fluoranthene Benzo[k]fluoranthene Benzo[g,h,i]perylene Chrysene Dibenz[a,h]anthracene Dibenzothiophene Fluoranthene Fluorene Indeno[1,2,3-cd]pyrene Phenanthrene Pyrene Cd, Cr, TBT, DBT Aroclor 1254	Acenaphthene Anthracene Benz[a]anthracene Benzo[a]pyrene Benzo[b]fluoranthene Benzo[k]fluoranthene Benzo[g,h,i]perylene Chrysene Dibenz[a,h]anthracene Dibenzothiophene Fluoranthene Indeno[1,2,3-cd]pyrene Phenanthrene Pyrene Cr TBT, DBT	Naphthalene Phenanthrene PCB congeners 31+28, 45, 49 and 49+43, 74, 85, 87, 99, 101 and 101+89, 110 and 110+77, 118 and 118+149, 134+114, 153+132+105, 163+138, 170+190

(Continued)

Table 9 (Concluded)			
Statistically Significant Comparison	Organism		
	Mussel	Clam	Fish
S50 > Day 0 (continued)	PCB congeners 22, 25, 32+16, 40, 44, 49 and 49+43, 56+60, 70+76, 74, 82, 83, 84 and 92+84, 85, 87, 91, 97, 99, 101 and 101+89, 110 and 110+77, 118 and 118+149, 128, 131, 134+114, 137+176, 149, 151, 153+132+105, 158, 163+138, 170+190, 177, 178, 183, 187+182, 198, 202+171	PCB congeners 22, 49 and 49+43, 56+60, 70+76, 74, 85, 99, 101 and 101+89, 110 and 110+77, 118 and 118+149, 134+114, 149, 151, 163+138, 170+190, 177, 187+182, 202+171	
PC > Day 0	Cd, TBT, DBT PCB congeners 18, 26, 45, 48+47, 56+60, 82, 87, 91, 97, 146, 172+197, 201, 203+196, 208+195	Cr, Hg PCB congeners 42+37	Phenanthrene Hg PCB congeners 18, 22, 74, 91
Day 0 > BS	--	--	PCB congeners 33 and 33+53, 64+41+71, 95+66, 131, 135+144, 157+200, 158, 173, 187+182, 193, 202+171, 208+195, lipid
Day 0 > S50	--	--	Cd PCB congeners 33 and 33+53, 64+41+71, 95+66, 131, 135+144, 157+200, 158, 173, 187+182, 193, 202+171
Day 0 > PC	Acenaphthene Benzo[b]fluoranthene Fluorene Naphthalene	--	PCB congeners 33 and 33+53, 95+66, 135+144, 157+200

Patterns of PCB bioaccumulation were inconsistent, with some PCBs apparently bioaccumulating preferentially from BS and others from S50 (Table A16). Aroclor 1254 bioaccumulation from S50 was significantly higher than from BS in mussels and fish (Figure B25), but not in all organisms combined (Table 8). The PCB congeners that had significantly higher bioaccumulation from BS than from S50 were: 8+5 (mussels, clams, and all organisms combined), 18 (mussels), 25 (clams), 26 (mussels), 31+28 (clams), 32+16 (mussels), 40 (mussels and clams), 63 (mussels), 141 (clams), 177 (clams), 183 (clams), and 187+182 (clams). The PCB congeners that had significantly higher bioaccumulation from S50 than from BS were: 31+28 (fish), 45 (fish), 46 (all organisms combined), 49+43 (fish), 56+60 (mussels), 70+76 (mussels), 82 (mussels), 85 (mussels), 87 (mussels and all organisms combined), 95+66 (fish), 99 (fish), 110+77 (mussels, fish, and all organisms combined), 118 (mussels, fish, and all organisms combined), 131 (mussels), 134+114 (mussels and fish), 135+144 (fish), 141 (fish), 170+190 (mussels), and 178 (mussels and all organisms combined).

Comparison of bioaccumulation among experiments

Bioaccumulation of PAHs, metals, organotins, and Aroclor 1254, and organism lipid content were compared among experiments in organisms that were exposed to BS and S50 for 28 days (Table A17). Significant comparisons for the primary contaminants of concern are summarized in Table 10 and illustrated in Figures B56 to B78. PAH comparisons could only be made between Reference and Hot, as PAHs from Inner and Outer were analyzed by a different laboratory and all were reported as < DL on a much higher scale (μg/g wet wt.) than the PAH residues reported for Reference and Hot (ng/g wet wt.). Bioaccumulation of every PAH in each of the organisms was significantly higher from Hot than from Reference (Figures B56 to B72), with the exceptions of acenaphthylene in clams and fish (Figure B57); and acenaphthene (Figure B56), dibenz[a,h]anthracene (Figure B65), dibenzothiophene (Figure B72), and fluorene (Figure B67) in fish. In many cases bioaccumulation of PAHs from Hot was one or two orders of magnitude higher than from Reference.

Bioaccumulation of Cd, Cr, and Hg during the different experiments followed no consistent pattern (Figures B73 to B75). Although significant differences among experiments were noted for all three metals in each of the organisms (Table 10), magnitudes of bioaccumulation were similar among experiments (Table A17). Metals bioaccumulation varied as little as 0.1 μg/g (Cd in clams, Hg in clams and fish), up to 6 μg/g (Cd in mussels, Cr in clams) among experiments.

TBT bioaccumulation was significantly greater, by one to two orders of magnitude, from Hot and Reference than from Inner in all three organisms (Table A76, Figure B61). Greater DBT bioaccumulation also occurred from Hot and Reference than from Inner (Figure B77), although differences among experiments were not significant for fish. MBT bioaccumulation pattern was Hot > (Reference, Inner) in mussels, Reference > (Hot, Inner) in clams, and all < DL in fish. Tissue samples from the Outer experiment were not analyzed for organotins.

Bioaccumulation of Aroclor 1254 was significantly greater from Outer and Hot than from Reference in all three organisms (Tables 10, A17), and was also significantly greater from Outer than from Hot in fish (Figure B78). Aroclor 1254 was < DL in all tissue samples from the Reference experiment, and was not analyzed from Inner experiment tissue samples.

Lipid content was significantly higher in mussels exposed to Inner and Reference than in mussels exposed to Outer and Hot, while the reverse was true for clams (Table A17). Lipid content of fish did not differ significantly among the experiments.

Table 10
Summary of Significant Statistical Comparisons Among Experiments for Bioaccumulation of Primary Contaminants of Concern

Contaminant	Statistical Comparison		
	Mussel	Clam	Fish
Acenaphthene	Hot > Reference	Hot > Reference	NS[1]
Acenaphthylene	Hot > Reference	NS	All below DL
Anthracene	Hot > Reference	Hot > Reference	Hot > Reference
Benz[a]anthracene	Hot > Reference	Hot > Reference	Hot > Reference
Benzo[a]pyrene	Hot > Reference	Hot > Reference	Hot > Reference
Benzo[b]fluoranthene	Hot > Reference	Hot > Reference	Hot > Reference
Benzo[k]fluoranthene	Hot > Reference	Hot > Reference	Hot > Reference
Benzo[g,h,i]perylene	Hot > Reference	Hot > Reference	Hot > Reference
Chrysene	Hot > Reference	Hot > Reference	Hot > Reference
Dibenz[a,h]anthracene	Hot > Reference	Hot > Reference	All below DL
Dibenzothiophene	Hot > Reference	Hot > Reference	All below DL
Fluoranthene	Hot > Reference	Hot > Reference	Hot > Reference
Fluorene	Hot > Reference	Hot > Reference	NS
Indeno[1,2,3-cd]pyrene*	Hot > Reference	Hot > Reference	Hot > Reference
Naphthalene	Hot > Reference	Hot > Reference	Hot > Reference
Phenanthrene	Hot > Reference	Hot > Reference	Hot > Reference
Pyrene	Hot > Reference	Hot > Reference	Hot > Reference
Cr	Hot > Outer > Inner > Reference	Reference > Hot (Inner, Outer)[2]	Reference > Outer (Inner, Hot)[4]
Cd	Outer > Hot > Inner > Reference	Outer, Reference > Hot (Inner)[3]	Outer > Inner, Hot, Reference
Hg	Outer > Hot > Inner > Reference	Hot, Reference > Inner, Outer	Outer > Hot, Reference (Inner)[5]
TBT	Hot > Reference > Inner	Hot, Reference > Inner	Hot, Reference > Inner
DBT	Hot, Reference > Inner	Hot > Reference, Inner	NS
Aroclor 1254	Hot, Outer > Reference	Outer, Hot > Reference	Outer > Hot > Reference

[1] NS = No significant differences detected in the statistical analysis.
[2] Inner and Outer not significantly different from Reference and Hot.
[3] Inner not significantly different from other experiments.
[4] Inner and Hot not significantly different from Reference and Outer.
[5] Inner significantly greater than Reference but not significantly different from Outer and Hot.

5 Discussion

OHDP Sediment Contaminant Levels Relative to Those of Other SF Bay Sediments and Sediments of Other Estuaries

Sediment inventories alone do not generally provide reliable information on the potential for bioaccumulation or for toxic effects of a sediment. Bioavailability is not addressed in sediment inventories, and has repeatedly been shown to be highly variable at similar levels of contamination. Neither do sediment inventories provide any insight into the interactive effects of complex mixtures of chemicals. This type of information can only be obtained by use of bioassays. For example, patterns of contaminant distribution in surficial San Francisco Bay sediments were recently surveyed by Long and Markel (1992) and their potentials for various toxicities were evaluated by reviewing the data of a compilation of bioassays. Sediment inventories can provide a general indication of severity of contamination at the high and low ends of the scale by comparing a particular site against others that have been demonstrated to be contaminated or clean. The relative contamination of the OHDP sediments with PAHs, PCBs, the metals Cr, Cd and Hg, and organotins can be put in perspective by comparison with levels reported in other San Francisco Bay sediments, and sediments of other industrialized harbors and estuaries that have been well studied.

Metals

Sediment inventories listing concentrations of heavy metals are generally the least reliable indications of bioavailability. Complex geochemical interactions determine whether and to what extent a given metal will be present in the form of free ion, and therefore available for uptake by an organism. Of the ten metals analyzed in the OHDP sediments (Table A2), only three (Cd, Cr, and Hg) showed appreciable bioavailability under the conditions of the FATES exposures. Therefore, this discussion will be confined to those metals. Table 11 lists the average terrestrial abundance of Cd, Cr, and Hg, and the concentrations analyzed in OHDP sediments. Concentrations reported in other San Francisco Bay surficial sediments and at other estuarine and marine sites are included for comparison.

Cadmium. The concentrations of Cd in the OHDP Inner, Outer, and Reference sediments did not differ from average abundance of Cd in the earth's crust by more than a factor of two. The Hot sediment was elevated in Cd content over terrestrial abundance by a factor of eight. This concentration was similar to levels reported for surficial OHDP Inner Harbor sediments, and was higher than concentrations analyzed in other SF Bay sediments. Cadmium concentrations of the two OHDP sediments and the Reference are comparable to surficial sediments previously analyzed at Yerba

Buena Island, San Pablo Bay, and Vallejo, and are less than concentrations measured in Tomales Bay, considered to be an uncontaminated area. By way of contrast, concentrations two orders of magnitude higher were reported in sediments of New York and Black Rock Harbors, both degraded areas.

Table 11
Terrestrial Abundance of Cd, Hg, and Cr, and Concentrations in OHDP Sediments, San Francisco Bay Surficial Sediments, and Sediments of Other Estuarine Locations

Location	Concentration, μg/g dry weight			Source
	Cd	Cr	Hg	
Terrestrial abundance	0.150	200	0.50	Van Nostrand's (1976)
OHDP Inner	0.091	561	0.050	This study
Outer	0.308	286	0.583	
Hot	1.208	450	0.005	
Reference	0.241	195	0.351	
San Francisco Bay, CA				Long et al. (1990)
Oakland Inner Harbor	1.78	189	8.33	
	1.06	190	1.48	
	1.19	182	2.12	
Vallejo	0.24	174	0.25	
	0.21	182	0.32	
	0.23	185	0.35	
Yerba Buena Island	0.57	168	0.42	
	0.32	144	0.22	
	0.44	235	0.36	
SW San Pablo Bay	0.28	182	0.29	
	0.30	178	0.23	
	0.28	178	0.26	
Tomales Bay, CA	0.43	234	0.38	
	0.47	147	0.51	
	0.40	237	0.44	
NW Mersey Estuary, England, UK	0.2 to 3.9	37 to 142	0.4 to 6.2	Langston (1986)
Chesapeake Bay	<0.1 to 1.47	NR[1]	NR	DiGiulio and Scanlon (1985)
Black Rock Harbor, CN	23.4	1,430	1.7	Lake, Hoffman and Schimmel (1985)
San Diego Harbor, CA				Salazar and Salazar (1985)
Commercial Basin	0.900	26.0	2.7	
North Island	0.700	15.0	0.098	
Coastal Marinas, SC	NR	6 to 35	NR	Marcus et al. (1988)
Puget Sound Surficial Sediments	0.3 to 0.418	NR	0.076 to 0.275	Bloom and Crecelius (1987)
Commencement Bay and Tacoma Waterways, WA	0.13 to 3.9	7.5 to 40.1	NR	Schults et al. (1987)

[1]Not reported.

(Continued)

Table 11 (Concluded)				
Location	Concentration, µg/g			Source
	Cd	Cr	Hg	
New York Harbor, NY	5.16 to 38.6	NR	2.71 to 34.89	Rubinstein, Lores and Gregory (1983)
New York Bight				Koepp et al. (1982)
Mud Dump Site	0.081	NR	0.242	
Mud Dump Site, 2 mi NE	0.058	NR	0.130	
Mud Dump Site, 1 mi SW	0.065	NR	0.104	
Jones Beach	0.054	NR	0.050	
Gravesend Bay	0.062	NR	0.041	
Barnegat Light	0.034	NR	0.037	
Capping Site	0.041	NR	0.030	
Cape May	0.050	NR	0.027	

Chromium. Chromium concentrations in the OHDP Outer and Reference sediments were near the average terrestrial abundance, as were the concentrations reported for surficial sediments at other SF Bay sites and in Tomales Bay (Long et al. 1990). Concentrations in the Outer and Hot sediments were somewhat more than double the terrestrial abundance for Cr, but about one-third the concentration reported in contaminated Black Rock Harbor sediment. Cr concentrations reported in sediments from San Diego Harbor, coastal South Carolina marinas, and Puget Sound waterways were typically about one-tenth the San Francisco levels.

Mercury. Concentrations of Hg in the Inner and Reference sediments were near the average terrestrial abundance level of 0.5 µg/g. Mercury concentrations in the other two OHDP sediments were anomolously low, with the concentration in the Hot sediment being reported as 0.005 µg/g. The low Hg concentration reported in the Hot sediment does not appear to be an error in the analysis. The six replicate analyses ranged 0.003-0.008 µg/g, and the standard Hg reference material analyzed 0.059 µg/g as compared with the certified concentration of 0.063 µg/g. The 0.351 µg/g reported for the Reference sediment appears to be fairly typical of SF Bay surficial sediments with the exception of some of the surficial sediments from OHDP Inner Harbor that measured as high as 8.33 µg/g. None of the OHDP sediments appear to be contaminated with mercury. Concentrations of Hg at other estuarine and marine locations included in Table 11 range from less than 0.1 to about 35 µg/g, and concentrations in a mercury-contaminated salt water marsh were reported at more than 1500 µg/g (Lee et al. in review).

Organotins

TBT and DBT were both present in low concentrations in the OHDP Inner, Outer, and Reference sediments relative to concentrations reported at other sites. The Hot sediment contained TBT and DBT at concentrations within the range of numerous harbor, channel, and marina sites in Chesapeake Bay, Boston Harbor, Puget Sound, and at Poole, UK (Table 12). The Hot sediment organotin concentrations were also within the range of sediments in composites from the surface to -38' MLLW in a separate OHDP study (Word et al. 1988). Concentrations two orders of magnitude higher than the TBT and DBT concentrations reported in the Hot sediment have been reported in severely contaminated sediments in the Chesapeake Bay and Puget Sound.

The low levels of organotins in the deep (-48' MLLW) OHDP sediments used in this study are expected and reflect the temporal record of the sediments. Organotin usage in antifouling paints was a recent practice.

Table 12
Organotins in OHDP Sediments and in Sediments of Other Estuaries

Location	ng/g Dry Weight		Source
	TBT	DBT	
OHDP Inner	3.46	2.35	This study
Outer	1.28	1.11	
Hot	67.26	12.84	
Reference	1.56	1.17	
Oakland Inner Harbor			Word et al. (1988)
Outer Reaches	18.7 to 179[1]	11.5 to 65.9	
Northern Turning Basin	37.1 to 105	35.2 to 67.8	
Southern Turning Basin	235 to 2214	70.6 to 658	
Chesapeake Bay			Espourteille, Greaves, and Huggett (1993)
Hampton Marina	up to 4000	NR[2]	
Elizabeth River	24 to 590	NR	
James River	2.4 to 59	NR	
Rappahonnock River	<14	NR	
Great Wicomico River	14 to 63	NR	
East Bay Shore	1.4 to 93	NR	
Occahannock Creek	1.4	NR	
Cherrystone Inlet	93	NR	
Chincoteague Bay	1.3	NR	
Folly Creek	5.8	NR	
Chesapeake Bay			Cited in: Hall (1988)
Back Creek	140 to 1390	NR	
Severn River	50	NR	
Sarah Creek	920 to 1300	NR	
Sarah Creek & Kings Creek	23 to 290	NR	
Poole Harbour, England, UK			Langston, Burt, and Mingjiang (1987)
Harbour Mouth	20[3]	10[3]	
Hales Bay (marina)	520[3]	570[3]	
Boston Harbor			Makkar, Kronick, and Cooney (1989)
Weymouth Back River	59 to 78	17 to 57	
Hewitt's Cove Marina	94 to 203	6 to 69	
Quincy Shipyard	10 to 180	8 to 43	
Marina Bay Y.C.	344 to 518	47 to 316	
Savin Hill Y.C.	92 to 98	8 to 139	
Reserved Channel	144 to 283	ND[4] to 35	
Fort Point Channel	9 to 32	16 to 26	
Charlestown Navy Yard	88 to 280	ND to 125	
Other sites	ND	ND	

[1]Range.
[2]Not reported.
[3]Quantitated as tin.
[4]Not detected.

(Continued)

Table 12 (Concluded)			
Location	ng/g dry weight		Source
	TBT	DBT	
Puget Sound			Krone et al. (1989a)
President Point	<1.5	<3.8	
Duwamish Waterway	<0.3 to 25	21 to 1300	
Everett Waterway	<0.47	11 to 210	
Shilsole Bay	<1.2 to 34	6.6 to 3300	
Bellingham Waterway	<29	<2.8 to 1900	
Seattle Waterfront	<6.7, 10	490, 590	
Kenmore Marina	<3.0	380	
Puget Sound			Krone et al. (1989b)
President Point	<0.45	<0.86	
Duwamish Waterway	14 to 25	570 to 1300	
Seattle Waterfront	<9.7	36 to 120	

Polynuclear aromatic hydrocarbons

Puget Sound. Concentrations of individual PAHs in the four OHDP sediments are comparable to the highest and lowest concentrations reported at sample sites in the Commencement Bay and Tacoma Waterways system in Puget Sound (Table 13). The highest concentrations reported for these areas were in sediments from the Sitcum City waterway (Schults et al. 1987), and these were similar to levels in the OHDP Hot sediment. The lowest concentrations reported were for sediments from the Brown's Point Reference Site, and sites toward the mouth of Commencement Bay. These concentrations were comparable to concentrations of PAHs in the OHDP Inner sediment. Other waterways in the system (Blair, Hyelobos, etc.), had intermediate PAH concentrations, and these were somewhat higher than the OHDP Outer and the Berkeley Flats Reference sediments. Concentrations of PAHs at the entrances of Tacoma waterways and in Commencement Bay matched or exceeded the full range of OHDP PAH concentrations. PAH concentrations in Elliott Bay (Pastorak and Becker 1989) were similar to or exceeded OHDP Hot concentrations in most cases. Concentrations of PAHs in Eagle Bay, a highly contaminated area of Puget Sound, were more than two orders of magnitude greater than the OHDP Hot sediment in some cases.

Chesapeake Bay. Sediments from the Southern Branch of the Elizabeth River, New Jersey (Alden and Butt 1987), are quite toxic in bioassays and have concentrations of individual PAHs similar to, and in some cases, several times greater than the OHDP Hot sediment. The concentrations of PAHs at "clean" sites in the Hampton Roads Harbor (Alden and Butt 1987) for the most part could not be quantitated as the detection limits were on the order of <30 to <310 ppb. These detection limits are generally greater than the concentrations of individual PAHs measured in the OHDP Outer, Inner, and Reference sediments. In the same study, concentrations of PAHs at transects of the Elizabeth River increased upstream and peaked in the area of highest industrialization with concentrations of PAHs similar to or exceeding those in the OHDP Hot sediment.

Table 13
Individual PAHs in OHDP Sediments, in Previously Collected San Francisco Bay Surficial Sediments, and in Sediments from Other Estuarine Locations

Location	Concentration, ng/g Dry Weight			Source
	Acn[1]	Acy[2]	An[3]	
OHDP Inner	1.80	1.34	3.68	This study
Outer	8.58	6.68	33.3	
Hot	1239	69.3	1766	
Reference	1.62	5.29	27.3	
San Francisco Bay				Spies et al. (1985)
Alameda	NR[4]	NR	13	
Berkeley	NR	NR	180	
Oakland	NR	NR	240	
San Pablo Bay	NR	NR	40	
Puget Sound				Pastorak and Becker (1989)
Commencement Bay	71	20	400	
Elliott Bay	430	98	2300	
Eagle Bay	81000	590	44000	
Hyelobos Ww[5]	NR	NR	56-338[6]	Schults et al. (1987)
Sitcum City Ww	NR	NR	435-1380	
Blair Ww	NR	NR	88	
Entrance of Ww's	NR	NR	66-118	
Commencement Bay	NR	NR	4-174	
Brown's Point	NR	NR	17	
Chesapeake Bay				Alden and Butt (1987)
Hampton Roads				
Harbor, D-E[7]	<260[8]	<240	<30	
Elizabeth River				
Mainstem, F-H	<260-2509	<240	<30-341	
Upstream, I-L	<260-438	<240, 230	<30-3413	
High Ind, M-P	115-1186	<240-2700	307-27300	
Upstream, Q-S	<260	<240	<240	
Coastal S. Carolina				Marcus et al. (1988)
Marinas				
Palmetto Bay	NR	NR	NR	
Outdoor Resorts	NR	NR	NR	
Fripp Island	NR	NR	NR	
Black Rock Harbor	NR	NR	NR	Lake, Galloway, and Hoffman (1987)
Long Island Sound	NR	NR	NR	

[1]Acenaphthene, [2]Acenaphthylene, [3]Anthracene. [4]Not reported. [5]Waterway. [6]Range. [7]Stations are indicated by letter designations and correspond to river mile; data is range of concentrations over indicated stations. [8]Detection limit. [9]Benz[a]anthracene, [10]Benzo[a]pyrene, [11]Benzo[b and/or k]fluoranthene, [12]Benzo[g,h,i]perylene, [13]Chrysene, [14]Dibenz[a,h]anthracene, [15]Fluoranthene, [16]Fluorene, [17]Indeno[c,d]pyrene, [18]Naphthalene, [19]Phenanthrene, [20]Pyrene.

(Sheet 1 of 5)

Table 13 (Continued)

Location	Concentration, ng/g Dry Weight			Source
	B[a]A[9]	B[a]P[10]	BF[11]	
OHDP Inner	19.7	46.8	79.8	This study
Outer	58.8	123	193	
Hot	2409	4306	7368	
Reference	116	193	223	
San Francisco Bay				Spies et al. (1985)
Alameda	25	22	NR	
Berkeley	180	330	NR	
Oakland	270	250	NR	
San Pablo Bay	110	130	NR	
Puget Sound				Pastorak and Becker (1989)
Commencement Bay	1100	NR	2200	
Elliott Bay	6100	NR	16000	
Eagle Bay	25000	NR	15000	
Hyelobos Ww[5]	161-1270	NR	NR	Schults et al. (1987)
Sitcum City Ww	422-3080	NR	NR	
Blair Ww	106-160	NR	NR	
Entrance of Ww's	31-146	NR	NR	
Commencement Bay	32-5881	NR	NR	
Brown's Point	NR	NR	NR	
Chesapeake Bay				Alden and Butt (1987)
Hampton Roads				
Harbor, D-E[7]	<50	<30-277	<35-302	
Elizabeth River				
Mainstem, F-H	<50-423	<30-1312	<35	
Upstream, I-L	<50-1991	366-16486	<35-2974	
High Ind, M-P	<50-1553	362-3324	217-17182	
Upstream, Q-S	283-1313	1652-2783	<35-2075	
Coastal S. Carolina				Marcus et al. (1988)
Marinas				
Palmetto Bay	5.3-62.8	1.7-44.3	1.2-63	
Outdoor Resorts	4.0-229	3.0-117	2.4-114	
Fripp Island	1.9-19.1	2.2-17.5	1.5-26.4	
Black Rock Harbor	NR	3900	NR	Lake, Galloway, and Hoffman (1987)
Long Island Sound	NR	250	NR	

(Sheet 2 of 5)

Table 13 (Continued)

Location	Concentration, ng/g Dry Weight			Source
	B[ghi]P[12]	Chry[13]	DBA[14]	
OHDP Inner	51.3	21.8	6.66	This study
Outer	137	71.3	13.2	
Hot	3261	3204	432	
Reference	128	106	5.09	
San Francisco Bay				Spies et al. (1985)
Alameda3	21	NR	NR	
Berkeley	260	NR	NR	
Oakland	350	NR	NR	
San Pablo Bay	170	NR	NR	
Puget Sound				Pastorak and Becker (1989)
Commencement Bay	1100	1200	240	
Elliott Bay	3300	10000	620	
Eagle Bay	1000	23000	420	
Hyelobos Ww[5]	NR	334-1250	NR	Schults et al. (1987)
Sitcum City Ww	NR	124-4560	NR	
Blair Ww	NR	15-184	NR	
Entrance of Ww's	NR	142-259	NR	
Commencment Bay	NR	NR	NR	
Brown's Point	NR	NR	NR	
Chesapeake Bay				Alden and Butt (1987)
Hampton Roads				
Harbor, D-E[7]	<35	<30-789	NR	
			NR	
Elizabeth River			NR	
Mainstem, F-H	<35	<30-1362	NR	
Upstream, I-L	<35-1079	409-13900	NR	
High Ind, M-P	<35-548	1120-3160	NR	
Upstream, Q-S	<35	1574-1745	NR	
Coastal S. Carolina				Marcus et al. (1988)
Marinas				
Palmetto Bay	6.3-7.3	9.7-144	NR	
Outdoor Resorts	3.8-16.1	9.5-674	NR	
Fripp Island	3.5-4.3	4.1-46	NR	
Black Rock Harbor	NR	NR	NR	Lake, Galloway, and Hoffman (1987)
Long Island Sound	NR	NR	NR	

(Sheet 3 of 5)

Table 13 (Continued)				
	Concentration, ng/g Dry Weight			
Location	Fla[15]	Fl[16]	I[c,d]P[17]	Source
OHDP Inner	28.5	1.66	38.9	This study
Outer	133	9.71	126	
Hot	7122	534	3600	
Reference	242	1.62	127	
San Francisco Bay				Spies et al. (1985)
Alameda	55	NR	NR	
Berkeley	330	NR	NR	
Oakland	400	NR	NR	
San Pablo Bay	140	NR	NR	
Puget Sound				Pastorak and Becker (1989)
Commencement Bay	2400	22	1100	
Elliott Bay	3800	1100	3900	
Eagle Bay	13000	84000	1900	
Hyelobos Ww[5]	353-2120	5-34	NR	Schults et al. (1987)
Sitcum City Ww	1100-8540	68-313	NR	
Blair Ww	310-499	11-13	NR	
Entrance of Ww's	93-938	12-57	NR	
Commencement Bay	31-151	1-5	NR	
Brown's Point	NR	NR	NR	
Chesapeake Bay				Alden and Butt (1987)
Hampton Roads				
Harbor, D-E[7]	<70-2021	<60	<50	
Elizabeth River				
Mainstem, F-H	<70-671	<60-220	<50	
Upstream, I-L	81-2156	<60-596	<50-372	
High Ind, M-P	1267-1984	155-24530	<50	
Upstream, Q-S	345-1061	<60-465	<50	
Coastal S. Carolina				Marcus et al. (1988)
Marinas				
Palmetto Bay	7.1-168	NR	9.8-16.5	
Outdoor Resorts	5.0-959	NR	1.8-37.6	
Fripp Island	273	NR	2.5-11.8	
Black Rock Harbor	6300	NR	NR	Lake, Galloway, and Hoffman (1987)
Long Island Sound	240	NR	NR	
				(Sheet 4 of 5)

Table 13 (Concluded)				
	Concentration, ng/g Dry Weight			
Location	Naph[18]	Phen[19]	Pyr[20]	Source
OHDP Inner	3.64	11.3	45.8	This study
Outer	19.9	68.3	211	
Hot	550	5053	7330	
Reference	19.2	111	252	
San Francisco Bay				Spies et al. (1985)
Alameda	NR	69	45	
Berkeley	NR	300	280	
Oakland	NR	580	330	
San Pablo Bay	NR	111	130	
Puget Sound				Pastorak and Becker (1989)
Commencement Bay	260	1000	2300	
Elliott Bay	320	13000	27000	
Eagle Bay	52000	180000	81000	
Hyelobos Ww[5]	44-81	176-587	372-1990	Schults et al. (1987)
Sitcum City Ww	169-589	453-3740	1040-7350	
Blair Ww	68	73-290	12-440	
Entrance of Ww's	90-546	214-639	22-1370	
Commencement Bay	67-128	6-29	9-87	
Brown's Point	NR	NR	3	
Chesapeake Bay				Alden and Butt (1987)
Hampton Roads				
Harbor, D-E[7]	<310	<50	<70	
Elizabeth River				
Mainstem, F-H	<310-821	<50-798	<70-2577	
Upstream, I-L	<310-1564	<50-1358	340-5179	
High Ind, M-P	417-953	527-5001	1075-2098	
Upstream, Q-S	<310	<50	714-846	
Coastal S. Carolina				Marcus et al. (1988)
Marinas				
Palmetto Bay	NR	17.8-81.1	17.8-212	
Outdoor Resorts	NR	22.6-1150	10.5-796	
Fripp Island	NR	54.5	22.0-90.2	
Black Rock Harbor	NR	5000	NR	Lake, Galloway, and Hoffman (1987)
Long Island Sound	NR	85	NR	

Black Rock Harbor. Sediments used in a study of bioaccumulation (Lake, Galloway, and Hoffman 1987) were collected at Black Rock Harbor, a contaminated location in Bridgeport, CN, and at an uncontaminated reference area in central Long Island Sound. Concentrations of PAHs measured in the Black Rock Harbor sediment were similar to the OHDP Hot sediment. In the same study, the concentrations of PAHs measured in the central Long Island Sound sediment were similar to those measured in the OHDP Reference sediment, and were greater than those measured in the OHDP Inner and Outer sediments.

South Carolina marinas. PAH content of sediments from sample sites in and around coastal South Carolina marinas bracketed the OHDP Inner, Outer, and Reference sediment concentrations and did not approach the OHDP Hot sediment concentrations (Marcus et al. 1988). No biological relationships were reported.

San Francisco Bay. In a previous study in which PAHs and PCBs were measured at sites in the San Francisco Bay System (Spies et al. 1985) individual PAHs were found at levels similar to, or somewhat higher than, concentrations measured in the OHDP Reference sediment (Table 13). Lowest concentrations were in sediments taken at an Alameda site and these were comparable to the OHDP Inner sediment PAH concentrations. Highest concentrations were in sediments from the Central Bay west of Oakland and from an area of the Berkeley Flats near the location of the OHDP Reference site. Somewhat lower concentrations were found in sediments from a site in San Pablo Bay, and these were most comparable to the OHDP Reference sediment PAH concentrations. Overall, the OHDP Reference sediment PAH concentrations are not largely different from concentrations in surficial sediments that have been measured at other San Francisco Bay sites. Long and Markel (1992) reported the total concentrations of 18 PAHs in SF Bay basins (San Pablo, Central, and South Bay) ranged from 2,600 to 3,900 parts per billion (ppb); total concentrations of PAHs were 7,200 ppb in OHDP Inner Harbor sediments and 62,700 ppb in Islais Creek sediments. Sums of the 15 PAH compounds in OHDP sediment (this study) were 363 ppb (Inner), 1,125 ppb (Outer), 48,243 ppb (Hot) and 1,559 ppb (Reference). These data support the premise underlying the use of the Reference site sediment, i.e., that the material is representative of sediments normally resuspended by wind and wave action, and transported throughout the Bay by tidal action and currents. The low contamination of the Inner sediment is evident, as is the high contamination of the Hot sediment.

Individual PAH comparisons

Acenaphthene (Acn) and acenapthylene (Acy). Acenaphthene is one of the three PAH compounds for which proposed sediment quality criteria (SQC) have been published by the USEPA. These proposed SQC have undergone numerous changes over the past several years and as of the time of this writing have no official standing. However, documents were made available through the National Technical Information Service in 1993 for acenaphthene, fluoranthene, and phenanthrene (Hanson et al. 1991a,b,c) and the SQCs published at that time are used here for comparisons. STORET data (cited in Hanson et al. 1991a) reportedly show concentrations of acenaphthene in sediments of United States rivers, lakes, and near coastal waters spanning a range of over seven orders of magnitude, with median concentration about 0.1 μg/g. The SQC for acenaphthene derived from a study using spiked sediments was reported as $\leq$ 240 μg acenaphthene/g organic carbon (Hanson et al. 1991a). The acenaphthene content of the Hot sediment is 112 μg/g organic carbon, falling below the proposed SQC by about one-half that value, and the Hot sediment would not be considered contaminated on the basis of its acenaphthene concentration. The Inner, Outer, and Reference sediments are far lower than the proposed SQC with 0.938, 1.38, and 0.175 μg acenaphthene/g organic carbon, respectively.

Data for sediment concentrations of acenaphthene and acenaphthylene in the literature are scant. In previously reported studies the detection limits for acenaphthene and acenaphthylene were well above the range at which the two PAHs were quantitated in the present study. Data from the Puget Sound and Chesapeake Bay studies included in Table 13 show concentrations of acenaphthene and acenaphthylene bracketing the concentrations measured in the OHDP Hot sediment. These areas are considered contaminated.

Anthracene (An). The concentration of anthracene in the OHDP Inner sediment (3.68 ng/g) is comparable to the lowest concentration measured in Puget Sound in the studies included in Table 13. This measurement is also less than the lowest concentration measured in San Francisco Bay surficial

sediments, 13 ng/g at Alameda (Spies et al. 1985). The OHDP Inner sediment can be said to be uncontaminated with anthracene. Concentrations of anthracene in the OHDP Outer and Reference sediments were comparable at 27.3 and 33.3 ng/g. These concentrations are similar to the concentration reported at the Brown's Point reference site, an uncontaminated area in Puget Sound, and the concentration reported for a San Pablo Bay site. The anthracene concentrations in the OHDP Outer and Reference sediments are 6- to 8-fold less than concentrations previously reported in surficial sediments from eastern San Francisco Bay shoal areas at Berkeley and Oakland. By way of contrast, the OHDP Hot sediment is on the order of 180-fold greater in anthracene concentration than the OHDP Outer and Reference sediments, and is in the range of the Puget Sound Elliott Bay and Sitcum City Waterways, and upstream reaches of the Elizabeth River. Both of these are considered areas of high PAH contamination.

Benz[a]anthracene (B[a]A). The concentration of benz[a]anthracene measured in the OHDP Inner sediment is less than the lowest concentrations reported at Puget Sound and Commencement Bay sites and is in the range reported at coastal South Carolina marinas. Benz[a]anthracene in the OHDP Outer and Reference sediment was similar to the lowest concentrations reported in the Puget Sound and Chesapeake Bay. At 2,409 ng/g, the concentration of benz[a]anthracene in the OHDP Hot sediment was 20- to 120-fold greater than any of the OHDP sediments or the Reference sediment, and was comparable to concentrations in other contaminated areas.

Benzo[a]pyrene (B[a]P). The concentration of benzo[a]pyrene in the OHDP Inner sediment was twice that previously reported at Alameda, but both Inner and Outer sediments were somewhat lower in benzo[a]pyrene than other surficial SF Bay sediments in the same study (Spies et al. 1985). Benzo[a]pyrene was not reported in either of the Puget Sound studies cited in Table 13. In the OHDP Hot sediment, the concentration of benzo[a]pyrene exceeded that reported in Black Rock Harbor and at most of the Elizabeth River sites.

Benzo[b+k]fluoranthene (BF). Data are scant for BF in the studies cited in Table 13. However, Inner, Outer, and Reference sediments fall within the range of concentrations reported for Hampton Roads Harbor, an area identified as "clean" (Alden and Butt 1987). The benzo[b+k]fluoranthene concentration in the Hot sediment is clearly comparable to that in other contaminated areas.

Benzo[g,h,i]perylene (B[ghi]P). All OHDP sediments exceed the full range of benzo[g,h,i]-perylene concentrations reported at coastal South Carolina marinas, but are generally less than concentrations previously reported in SF Bay surficial sediments with the exception of Alameda. The Hot sediment exceeded the benzo[g,h,i]perylene concentration range reported for the most contaminated reach of the Elizabeth River and was nearly the same as reported for Elliott Bay in Puget Sound.

Chrysene (Chry). Chrysene in the OHDP Inner, Outer, and Reference sediments was within the range reported for coastal South Carolina marinas and in nearly all cases below the ranges of concentrations given for Chesapeake Bay and Puget Sound. Again, the OHDP Hot sediment was comparable to other contaminated sites.

Dibenz[a,h]anthracene (DBA). Very few data are available for dibenz[a,h]anthracene in sediments. The OHDP Hot sediment was 33- to 85-fold greater in dibenz[a,h]anthracene concentration than the OHDP Inner, Outer, and Reference sediments, and was within the range of concentrations reported for sediments in contaminated regions of Puget Sound.

Fluoranthene (Fla). The OHDP Inner, Outer, and Reference sediments contained fluoranthene concentrations within the range reported for coastal South Carolina marinas. The Reference and Hot sediments were highly comparable to Long Island Sound (clean) and Black Rock Harbor (contaminated), respectively. An SQC of 1,340 μg/g organic carbon in sediments has been proposed for fluoranthene (Hanson et al. 1991a). The fluoranthene SQC and others based on the equilibrium partitioning approach have been the subjects of intense interagency scrutiny and debate. SQCs have no weight in law or regulation, but comparison of these values with results of the OHDP study and with published data is of interest. The Hot sediment is about one-half the proposed criterion (642 μg/g organic carbon) and the Reference, Inner, and Outer sediments are far less than the criterion at 14.8, 21.4, and 26.28 μg/g organic carbon, respectively.

Fluorene (FL). Fluorene concentrations in the OHDP Inner, Outer, and Reference sediments were similar to the lowest concentrations reported for Puget Sound. The Hot sediment with 534 ng/g was on the order of 50 to 300 times more contaminated than Inner, Outer, and Reference. This concentration appears to be comparable to moderately contaminated reaches of the Elizabeth River, is one-half the concentration reported for Elliott Bay sediments (contaminated), and is about 160 times less contaminated than sediments of Eagle Bay.

Indeno[1,2,3-cd]pyrene (I[cd]P). Few data reporting indeno[1,2,3-cd]pyrene concentrations in sediments are available for comparison. Concentrations of I[cd]P in OHDP Inner, Outer and Reference follow the pattern described for other PAHs in these sediments. The lowest concentration analyzed was in the OHDP Inner sediment. Outer and Reference were similar, and were greater than Inner by about a factor of three. I[cd]P in all the OHDP sediments was above the range reported for coastal South Carolina marinas. The Hot sediment was about 30 to 90-fold more contaminated than the OHDP sediments, and was similar in I[cd]P concentration to sediment from Elliott Bay.

Naphthalene (Naph). Naphthalene concentrations in OHDP Inner, Outer, and Reference were lower than in any other study cited in Table 13. The naphthalene concentration in the Hot sediment was similar to others reported for contaminated sediments, but still about 100-fold lower than reported in the severely contaminated Eagle Bay sediment.

Phenanthrene (Phen). The concentration of phenanthrene in the OHDP Inner sediment was the same as previously reported for Alameda surficial sediments (Spies et al. 1985). Similarly, the phenanthrene concentration in Reference was the same as reported for San Pablo Bay, with the concentration in Outer being intermediate between the two. The phenanthrene concentration in OHDP Hot sediment was comparable to concentrations reported for other contaminated areas, but far less than Elliott Bay or Eagle Bay. An equilibrium partitioning-based SQC of 160 μg/g organic carbon in sediments has been proposed for phenanthrene (Hanson et al. 1991b). The Hot sediment (455 μg/g organic carbon) exceeds this proposed criterion and the Reference, Inner, and Outer sediments are far less than the proposed criterion at 12.04, 5.97, and 10.98 μg/g organic carbon, respectively.

Pyrene (Pyr). Concentrations of pyrene followed the pattern described for most of the other PAH compounds analyzed in the OHDP Inner and Outer sediments and the Hot and Reference sediments. OHDP Inner contained the lowest concentration of pyrene, and this was similar to the Alameda surficial sediment previously reported (Spies et al. 1985). OHDP Outer and Reference were similar and somewhat less than the Berkeley and Alameda surficial sediments in the same study. Pyrene in these three sediments was greater than the lowest concentrations reported for coastal South Carolina

marinas and the least contaminated sediments of Commencement Bay. The Hot sediment was about 30- to 160-fold greater in pyrene contamination than OHDP Inner, Outer, or Reference, but comparable to contaminated sediments in the Elizabeth River and some of those in Puget Sound.

Comparison with screening level concentrations

It is not the purpose of this report to consider the merits or demerits of the numerous approaches that have been proposed for assessing sediment quality or for establishing SQCs. However, as with the proposed SQCs based on equilibrium partitioning, it may be instructive to apply another of these approaches in discussing relative PAH contamination of the OHDP sediments. Screening Level Concentrations, SLCs (Neff et al. 1988) are described as the concentrations of contaminants in a sediment below which a normal, abundant, benthic population has been shown to exist. Concentrations above the SLC are considered to be contaminated and are expected to adversely affect a benthic population. For neutral organic chemicals like the PAHs, the magnitude of an SLC for a given sediment is a linear function of the organic carbon content of the sediment.

Table 14
Mean Concentrations of PAHs in OHDP Sediments Compared with Screening Level Concentrations[1] (SLC)

PAH	Mean or Screening Level (SLC)	Concentration, ng/g, dry weight			
		Inner	Outer	Hot	Reference
Acenaphthylene	Mean	1.34	6.68	69.3	1.62
	SLC	9.5	28	52	43
Anthracene	Mean	3.68	33.3	1766	27.3
	SLC	33	98	179	147
Benz[a]anthracene	Mean	19.7	58.8	2409	116
	SLC	52	156	286	234
Benzo[a]pyrene	Mean	46.8	123	4306	193
	SLC	79	237	435	356
Chrysene	Mean	21.8	71.3	3204	106
	SLC	77	231	424	347
Fluoranthene	Mean	28.5	133	7122	242
	SLC	129	386	708	579
Fluorene	Mean	1.66	9.71	534	1.62
	SLC	20	61	111	91
Phenanthrene	Mean	11.3	68.3	5053	111
	SLC	74	221	405	331
Pyrene	Mean	45.8	211	7330	252
	SLC	133	399	732	599

[1]Neff et al. (1988).

Table 14 shows the mean concentrations of nine PAHs in OHDP sediments and the SLCs calculated for each sediment. In each case the concentration of PAH in the OHDP Inner, Outer, and Reference sediments is less than the corresponding SLC. However, also in each case, the PAH concentration of the OHDP Hot sediment exceeds the SLC. In many cases the difference is a factor of ten. Of the four sediments included in the present study, only the Hot would be considered

contaminated with PAHs based on SLCs. This is also the conclusion one would draw from the sediment chemistry comparisons. However, except for the extremes in the study, conclusions based on sediment chemistry alone are risky and cannot be considered definitive.

Polychlorinated biphenyls

The polychlorinated biphenyls in sediments included in the present study most closely resembled the composition of the A1254 chromatographic standard and were quantitated as such. The chromatographic profiles of other San Francisco Bay sediment samples have also been seen to resemble A1254 more closely than other Aroclor mixtures (Phillips and Spies 1988). Table 15 shows concentrations of PCBs in sediments of the present study, previous studies involving sediments of the San Francisco Bay system, and in other estuarine and marine locations in the United States. The studies included are not exhaustive, but were considered to provide a good indication of relative levels of sediment PCB contamination. In compiling the data, studies in which PCBs in sediments were reported as A1254 were sought. In one case, data reported as A1242 were included (Bopp et al. 1981) and in several cases total PCBs were reported. The A1242 data were included because they describe one of the most severely contaminated river/estuarine systems in America (tidal Hudson River, NY). It is more common to find PCBs reported in the literature as total PCBs rather than as specific Aroclor mixtures.

Environmental contamination with PCBs began with point source discharges of Aroclors, each having its own standard composition of individual PCB congeners. Through processes of mixing and partial degradation by photochemical and bacterial action, the PCB mixtures found in sediments do not usually correspond well to any one standard Aroclor (McFarland and Clarke 1989). Apparently, the PCBs analyzed in sediments of the present study, and in some other SF Bay sediments, are an exception.

Like other industrialized estuaries, the San Francisco Bay system contains localized areas of high PCB contamination. The most severe of these are generally in the upper reaches of the Bay at the Port of Stockton and in Suisun Bay. Islais Creek on the San Francisco side of the Bay has also been identified as an area of PCB contamination. The OHDP Inner sediment and the Reference sediment are low in PCB contamination (2.6 and 3.3 ng/g, respectively), and the OHDP Outer sediment has PCBs in the range previously reported for sediments for the Central Bay (48.6 ng/g). The Hot sediment (475.9 ng/g) is contaminated, but to a lesser extent than the Port of Stockton area, some Bay area streams, and other waterways considered to be major PCB problem areas. PCB concentrations in sediments of the Palos Verdes Shelf, New Bedford Harbor, New York Harbor and Bight Apex, Newark Bay, and the Passaic River are commonly on the order of several to tens of parts per million. By comparison the OHDP sediments appear to have a very low order of PCB contamination.

Table 15
PCBs in OHDP Sediments and in Sediments of Other Estuarine and Marine Locations

Location	Concentration, ng/g Dry Weight	Source
OHDP Inner	2.6[1]	This study
Outer	48.6[1]	
Hot	475.9[1]	
Reference	3.3[1]	
San Francisco Bay-Delta:		
San Pablo Bay	5.71 to 17.45[2]	Chapman et al. (1986)[3]
Oakland	26.57 to 36.84[2]	
Islais Creek	57.31 to 255.26[2]	
San Pablo Bay	9[2]	NOAA (1987)[3]
Southampton Shoal	12[2]	
Oakland	40[2]	
Port of Stockton Area	7,100 to 17,800[2]	Rice et al. (unpubl.)[3]
East Bay Mudflats	50 to 90[2]	
Oakland Inner, Middle Harbor, & Suisun Bay	100 to 608[2]	
Oakland Inner Harbor	305 to 421[2]	Long et al. (1990)
Yerba Buena Island	52.8 to 73.5[2]	
Vallejo	20.3 to 53.4[2]	
SW San Pablo Bay	20.6 to 27.0[2]	
Bay Area Streams	1.2 to 1,400[2]	Law and Goerlitz (1974)[3]
Tomales Bay, CA	4.2 to 10.4[2]	Long et al. (1990)
Escambia Bay, FL	<30 to 1,700[1]	Duke, Lowe, and Wilson (1970)
Upper Escambia Bay, FL	5,000[1]	Nimmo et al. (1974)
Palos Verdes Shelf, CA	80 to 13,000[1]	Young, McDermott-Ehrlich, and Heessen (1977)
Commencement Bay and Tacoma Waterways, WA	24 to 1220[1]	Schults et al. (1987)
Long Island Sound, NY	15 to 48[1]	Lake et al. (1990)
Narragansett Bay, RI	27 to 328[1]	
New Bedford Harbor, MA	3,070 to 9,200[1]	
Santa Monica Bay, CA	47, 95[1]	Ferraro et al. (1990)
Palos Verdes Shelf, CA	590, 1,640[1]	
Palos Verdes Shelf, CA	1,760, 4,740[1]	
Tidal Hudson River, NY	3,000 to 30,000[4]	Bopp et al. (1981)
Raritan Bay, NY	110[2]	Stainken and Rollwagen (1979)
New York Bight Apex, NY	0.9 to 2,200[2]	West and Hatcher (1980)
New York Harbor, NY	460 to 7,280[2]	Rubinstein, Lores, and Gregory (1983)
Newark Bay, NJ	5,880[2]	Rubinstein, Gilliam, and Gregory (1984)
Passaic River, NJ	3,550[2]	Rubinstein, Pruell, and Taplin (1990)

PCBs quantitated as: [1]A1254.
[2]Total PCB.
[3]Cited in Phillips and Spies (1988).
[4]A1242.

Bioaccumulation of Contaminants from OHDP Sediments

Metals

Cadmium. The concentrations of metals and organotins that had bioaccumulated to statistically significant levels in the three organisms at the end of each of the four sediment exposures are shown in Table 16. Cadmium was not bioaccumulated to statistically significant concentrations by clams or by fish in any exposure. Highest concentrations of Cd bioaccumulated by the mussels (8.9 and 9.2 μg/g, dry wt.) were in exposures to bedded and suspended Outer sediment. These Cd levels are greater by more than a factor of ten than concentrations measured in East coast *M. edulis* caged at the New York Bight Mud Dump Site (Koepp et al. 1982). Species of *Mytilus* from various regions of the world have been analyzed for Cd with concentrations reported from below DL in New Zealand to as high as 127 μg/g in samples from Australia (Table 17).

Rule and Alden (1990) related Cd bioaccumulation in *M. edulis* to the relative amounts of operationally defined geochemical phases in sediments. Although in a series of sediments the highest concentrations of Cd were always associated with the organic-sulfide phase, the controlling phases for bioavailability of Cd to the mussels were the exchangeable phase (EP) and the easily reducible phase (ERP). The EP fraction was removed in the first step of the sequential extraction process. This fraction was considered to contain the most bioavailable metals and was obtained using neutral pH 1N-ammonium acetate. The second step (ERP) involved extraction with hydroxylamine in dilute nitric acid and obtained the metals bound to hydrous manganese oxides. Of the two phases, high ERP correlated most strongly with Cd bioavailability to the mussels. High EP and ERP content characterized the sandy sediments (95.9 percent sand) in the studies reported by Rule and Alden (1990). High sand content was not characteristic of the sediments that produced Cd bioaccumulation in the present study. However, the data indicate that a water-mediated pathway for Cd from sediment to organism is at least as important as direct exposure through filtration of contaminated particulates. This is implied by the relationship of *M. edulis* in the present study to the contaminated sediments. In the experiments reported here the mussels were never exposed to contaminated suspended particulates in the bedded sediment aquaria, and yet bioaccumulation of Cd in mussels is nearly identical in bedded and suspended sediment exposures. The water route is also predicted by the correlation of high bioavailability with high EP and ERP (Rule and Alden 1990). It appears that although the Cd content of the OHDP sediments is low, Cd in the Outer sediments is bioavailable, and open water disposal could result in some contribution of Cd to the body burden of exposed *M. edulis*.

Table 16
Significant Bioaccumulation of Metals and Organotins. Tissue Concentrations at Day 28, μg/g Dry Weight (Metals) or ng/g Dry Weight[1] (Organotins)

Organism	Inner		Outer		Reference		Hot	
	BS[2]	S50[3]	BS	S50	BS	S50	BS	S50
Cadmium								
M. edulis	*[4]	*	8.90	9.20	*	3.78	6.53	6.75
C. stigmaeus	*	*	*	*	*	*	*	*
M. nasuta	*	*	*	*	*	*	*	*
Chromium								
M. edulis	1.78	1.36	1.55	3.25	0.718	0.615	4.02	3.60
C. stigmaeus	2.37	*	*	*	*	*	0.990	*
M. nasuta	16.0	4.59	*	14.0	8.15	7.83	5.52	3.82
Mercury								
M. edulis	*	*	*	*	*	*	0.285	*
C. stigmaeus	*	*	*	*	*	*	0.270	*
M. nasuta	*	*	*	*	0.144	0.160	0.165	0.142
Tributyltin								
M. edulis	*	*	*	*	144	132	493	259
C. stigmaeus	*	*	*	*	60.4	44.6	48.9	*
M. nasuta	16.0	*	*	*	123	103	117	143
Dibutyltin								
M. edulis	*	*	*	*	64.5	54.1	99.7	43.8
C. stigmaeus	*	*	*	*	*	*	*	*
M. nasuta	*	*	*	*	*	15.1	*	*
Monobutyltin								
M. edulis	*	*	*	*	*	*	*	*
C. stigmaeus	*	*	*	*	*	*	*	*
M. nasuta	*	*	*	*	*	31.2	*	*

[1] Converted from ng/g wet weight, Tables A11 and A12.
[2] Bedded sediment.
[3] 50 mg/L Suspended sediment.
[4] Not detected, or not significant compared to background levels if detected, $P_{crit} \leq 0.025$.

Table 17
Ranges of Cd Concentrations (μg/g Dry Weight) Reported in *Mytilus* From Different Regions of the World[1]

Region	Range	Region	Range
New Zealand	BDL[2]	Mediterranean	0.8-6.8
Sicily	0.78-3.15	Scandinavia	0.4-12.9
Quebec	1.12-3.2	Australia	0.24-18.16
SW Europe	1.7-3.6	Australia	2.8-63
Norway	BDL-5.0	England	0.5-65.4
California	BDL-5.8	Australia	0.11-127
NW Mediterranean	0.4-5.9		

[1] Adapted from Cossa and Bourget (1980). Complete citations given in that article.
[2] Below detection limit.

Chromium. Cr is much less frequently reported as a major heavy metal contaminant in aquatic systems than are, e.g., Hg, Cd, Pb, Cu, or Zn. However, Cr was the only metal that bioaccumulated from the OHDP Inner sediment, and showed statistically significant elevations in all three organisms. All of the sediments tested produced Cr bioaccumulation to significant levels in clams and mussels. Higher levels resulted from exposure to bedded than to suspended sediment in all cases except in clams and mussels exposed to OHDP Outer sediments (Table 16). The highest bioaccumulation of Cr in *M. nasuta* from the OHDP sediments was 16 μg/g dry wt. from Inner sediment in the bedded sediment exposure. Nearly the same concentration of Cr (14 μg/g) was bioaccumulated from the Outer suspended sediment exposure. These concentrations exceed Cr residues measured in several taxa collected at the Mud Dump Reference Site (MDRS) in the New York Bight Apex, but are less than concentrations of Cr measured in two taxa at that site (McFarland, Lutz, and Reilly in review). Mean Cr concentrations in *Nucula* sp., *Mercenaria mercenaria*, miscellaneous mollusca, and *Nephtys* sp. ranged from 3.55 to 10 μg/g dry wt., but were 22 μg/g in Lumbrineridae and 133 μg/g in miscellaneous polychaetes collected in the same benthic grab samples. Although Cr concentrations measured in *M. nasuta* exposed to Reference and Hot sediments showed statistically significant increases at the end of the exposures, all were less than 10 μg/g. The highest Cr bioaccumulation in the mussels was 4.02 μg/g in the Hot bedded sediment exposures. By comparison, *M. edulis* exposed to suspended Black Rock Harbor sediments for 28 days bioaccumulated Cr to a mean concentration of 25.1 μg/g dry wt. (Lake, Hoffman, and Schimmel 1985). The flatfish bioaccumulated Cr to statistically significant concentrations only in exposures to bedded Inner and Hot sediments.

Chromium bioaccumulated in *M. edulis* to nearly the same concentrations in mussels exposed indirectly through the water column to bedded sediments, as in mussels directly exposed to suspended sediments. Like Cd, the pattern of Cr uptake indicates a water-mediated route for bioaccumulation of the metal from the OHDP sediments, and a potential exists for some contribution of Cr to the body burden of exposed bivalves from the OHDP sediments.

Mercury. Hg was not significantly bioaccumulated from Inner or Outer sediments, but was bioaccumulated from Reference and Hot. The Hg tissue residues were similar in the bedded and suspended exposures (0.142-0.165 μg/g dry wt.), and were within the range (0.07-0.31 μg/g dry wt.) measured in seven taxa at the New York Bight Apex MDRS (McFarland, Lutz, and Reilly in review). When *M. nasuta* were exposed in the laboratory for 28 days to bedded estuarine sediments from the New York Bight, mean Hg concentrations ranged from 0.23 μg/g dry wt. (Sandy Hook sediment) to 0.39 μg/g (Red Hook sediment). In neither laboratory test of bioaccumulation did 28-day Hg tissue residues correlate with concentrations in sediment. Mercury concentrations ranged from 0.005 parts per million (ppm) (Hot sediment) to 0.583 ppm (Outer sediment) in the OHDP experiments, and concentrations in the New York Bight sediments ranged from <0.1 to 15.8 ppm. Concentrations of total Hg in a related species, *M. balthica*, were reported to range from 0.15 to 2.26 ppm in British estuaries (Langston 1982). Total Hg in *M. balthica* collected at a site considered to be influenced by a former mercurial fungicide factory in Denmark was reported as 1.4 ppm (Riisgård et al. 1985). By comparison, the Hg accumulated from the Reference or Hot sediments was at the low end of the range reported for *Macoma*.

The Food and Drug Administration (FDA) action level for Hg in edible fish is 1.0 μg/g methylmercury. The Japanese use a Safety Guideline for fish of 0.4 μg/g total Hg. Whereas total Hg exceeds methylmercury concentrations measured in the same individual in mussels (*Mytilus galloprovincialis*) by factors of as much as 400, in fish nearly all the Hg is present as methylmercury (Mikac

et al. 1985). Fish species selected for monitoring in Minimata Bay, where total Hg concentrations in the sediment exceed 25 μg/g, had tissue concentrations of Hg ranging from 0.281 to 0.974 μg/g between 1974 and 1980 (Nakayama et al. 1987). Flatfish and the mussels in the present study both bioaccumulated Hg from the bedded Hot sediment to concentrations similar to the low end of the Minimata Bay range for fish (0.270 and 0.285 μg/g, respectively) but showed no significant Hg bioaccumulation in any other exposure.

The fact that the Hg concentration in the Hot sediment was more than three orders of magnitude lower than the Hg concentration in the Outer sediment--which produced no bioaccumulation in any organism--points to the lack of correspondence between bulk Hg concentrations in sediment and potential bioavailability to organisms. The pattern of Hg uptake in the three species of the present study indicates a predominantly direct mode of transfer from sediment to organism for Hg, and contrasts with Cd which appears to have a predominantly water-mediated bioavailability. This direct transfer from sediment is consistent with the results of a laboratory study in which water-mediated and direct-from-sediment Hg transfer to fish were assessed quantitatively. Mercury bioaccumulated by guppies directly from bedded sediments was nine-fold greater than Hg uptake when the fish were isolated from direct contact with the contaminated sediments (Kudo and Mortimer 1979).

Differences in the geochemical determinants of Hg and Cd bioavailability were also reported by Breteler and Saksa (1985). In exposures of two species of mussels to metals-contaminated sediments, the concentrations of both Cd and Hg desorbed from the sediment to the water column correlated with uptake in the organisms. In addition, for both metals the initial 1N-HCl extractable concentrations also correlated highly with concentrations bioaccumulated. Final 1N-HCl extractable Hg correlated with Hg uptake whereas the same was not true for Cd. Instead, Cd uptake was strongly correlated with sediment total organic matter, and Hg uptake was not. These observations were interpreted in terms of differential strength of binding for the two metals. Binding of metal ions by sediment organic matter sequesters them and reduces the concentration of free ions available for uptake by organisms. Breteler and Saksa (1985) concluded that since cadmium binds to organic matter much less strongly than does Hg, more free Cd capable of being bioaccumulated is associated with the organic matter than is Hg. Of the four OHDP sediments, the highest in organic carbon content was the Hot sediment. It does not appear from either the results of exposures reported here or from geochemical considerations that Hg bioaccumulation from the OHDP sediments warrants concern.

Organotins

Organotin concentrations were converted to a dry weight basis in Table 16 for greater comparability with published data. With the exception of *M. nasuta* exposed to bedded OHDP Inner sediment, all instances of statistically significant bioaccumulation of organotins in the three species occurred in exposures to Reference and Hot sediments. Bioaccumulation of TBT appears to occur in the clam equally as well from suspended as from bedded sediment. The degraded organotins (DBT and MBT) were present in statistically significant concentrations only in clams exposed to suspended Reference sediment. Concentrations of TBT were highest in *M. edulis* exposed to bedded sediments and ranged from 132 to 493 ng/g in that species, with the highest concentrations resulting from exposure to Hot sediments. Clams bioaccumulated organotins to lower levels than mussels (103-143 ng/g TBT), and flatfish showed the least bioaccumulation with 44.6-60.4 ng/g TBT. In 10-day exposures of *M. nasuta* to OHDP Inner Harbor sediments taken by gravity corer to -38' MLLW, tissue concentrations of TBT ranged from 26.9 to 140 ng/g, dry wt. conversion (Word et al. 1988). In the same organ-

isms, DBT concentrations were 11.9-20 ng/g, and MBT concentrations were non-detectable to 11.9 ng/g. As expected, the Inner Harbor new work sediments (-48' MLLW) are substantially less contaminated with organotins than are the nearer surface, more recent sediments. Although bioaccumulation of TBT in *M. nasuta* from the bedded Inner sediment was statistically significant, it was about eight-fold less than concentrations resulting from exposure to Reference or Hot sediment (103-143 ng/g).

Organotins in *M. edulis* and in oysters, *Crassostrea sp.*, have been surveyed extensively in the Mussel Watch Program[1] (Garcia-Romero et al. 1993, Uhler et al. 1993). Mussels collected in SF Bay were reported having organotin concentrations similar to or exceeding those measured in *M. edulis* exposed to Reference and Hot sediments. Mussels collected at the Dumbarton Bridge in South SF Bay during the period 1989-1990 contained 230 ng/g TBT and 130 ng/g DBT. At the San Mateo Bridge, concentrations were 560 ng/g TBT and 210 ng/g DBT. The highest concentrations were reported for Emeryville in eastern Central SF Bay at 910 ng/g TBT and 610 ng/g DBT. These data clearly indicate a substantial degree of organotin contamination in the SF Bay system, particularly when compared with unimpacted areas of California such as Santa Cruz Island (Fraser Point) or the jetty at Humboldt Bay where concentrations of TBT and DBT in *M. edulis* were both on the order of 10 ng/g. These comparisons indicate no potential for degradation of the SF Bay system with organotins due to in-Bay disposal of OHDP sediments.

PAHs

No statistically significant bioaccumulation of any PAH compound occurred in any organism exposed to OHDP Inner or Outer sediments. Table 18 shows statistically significant concentrations of individual PAH compounds bioaccumulated above background (Day 0) concentrations by each of the three species exposed to the Reference and Hot sediments.

PAHs in flatfish. Flatfish exposed to the Reference sediment bioaccumulated no PAH compounds from the BS exposure, and only a trace amount of one PAH compound, benz[a]anthracene, from the S50 exposure. Flatfish exposed to Hot sediment bioaccumulated slightly more phenanthrene and naphthalene from suspended than from bedded sediment, but bioaccumulated no other PAH compounds. It was previously reported that naphthalene and phenanthrene can both bioaccumulate as the parent compound in fish, whereas the other PAH compounds do not (Gerhart et al. 1981, McCarthy and Jimenez 1985). Neither phenanthrene nor naphthalene are mutagenic/carcinogenic, but naphthalene is toxic to fish. For example, the 96-hr LC_{50} for naphthalene in fathead minnows, *Pimephales promelas*, was reported as 6.14 mg/L (CLSES 1985) and as 7.9 mg/L (DeGraeve et al. 1982). The LC_{50} to rainbow trout, *Oncorhynchus mykiss*, was 1.6 mg/L in the latter study. In embryo-larval tests using fathead minnows, growth was significantly reduced at 0.85 mg/L, and the highest no effect concentration was 0.45 mg/L (DeGraeve et al. 1982).

[1]National Oceanic and Atmospheric Administration National Status and Trends Mussel Watch Program.

Table 18
Significant Bioaccumulation of PAH Compounds. Tissue Concentrations at Day 28, ng/g Wet Weight

	Reference		Hot		Reference		Hot	
Organism	**BS**[1]	**S50**[2]	**BS**	**S50**	**BS**	**S50**	**BS**	**S50**
	Acenaphthene				**Benzo[k]fluoranthene**			
M. edulis	*[3]	*	*	8.33	*	*	*	407
C. stigmaeus	*	*	*	*	*	*	*	*
M. nasuta	*	*	53.2	39.6	*	*	204	231
	Acenaphthylene				**Benzo[g,h,i]perylene**			
M. edulis	*	*	6.12	11.1	*	*	*	172
C. stigmaeus	*	*	*	*	*	*	*	*
M. nasuta	*	*	*	*	4.54	5.91	100	117
	Anthracene				**Chrysene**			
M. edulis	*	*	13.8	42.5	*	*	*	925
C. stigmaeus	*	*	*	*	*	*	*	*
M. nasuta	*	*	237	216	*	*	630	697
	Benz[a]anthracene				**Dibenz[a,h]anthracene**			
M. edulis	*	2.03	217	623	*	*	12.2	16.7
C. stigmaeus	*	0.355	*	*	*	*	*	*
M. nasuta	*	*	452	492	*	*	24.8	26.6
	Benzo[a]pyrene				**Dibenzothiophene**			
M. edulis	*	*	235	615	*	*	2.94	9.14
C. stigmaeus	*	*	*	*	*	*	*	*
M. nasuta	4.48	5.26	320	379	*	*	43.4	42.5
	Benzo[b]fluoranthene				**Fluoranthene**			
M. edulis	*	*	387	872	*	10.3	311	1075
C. stigmaeus	*	*	*	*	*	*	*	*
M. nasuta	7.40	10.0	425	488	8.92	*	1785	1871
	Fluorene				**Phenanthrene**			
M. edulis	*	*	*	6.77	*	*	49.5	138
C. stigmaeus	*	*	*	*	*	*	26.9	36.7
M. nasuta	*	2.00	32.2	*	*	*	634	810
	Indeno[1,2,3-cd]pyrene				**Pyrene**			
M. edulis	*	*	51.5	136	16.0	8.42	*	294
C. stigmaeus	*	*	*	*	*	*	*	*
M. nasuta	4.15	4.22	72.0	85.3	*	*	1750	1958

[1] Bedded sediment.
[2] 50 mg/L Suspended sediment.
[3] Not detected, or not significant if detected, $P_{\alpha/2} \leq 0.025$.

(Continued)

Table 18 (Concluded)								
	Reference		Hot		Reference		Hot	
Organism	BS[1]	S50[2]	BS	S50	BS	S50	BS	S50
	Naphthalene				Total of 17 Individual PAH			
M. edulis	*	*	*	*	16.0	20.8	1194	5447
C. stigmaeus	*	*	53.4	80.9	*	0.355	80.3	118
M. nasuta	*	*	*	*	29.5	27.4	6743	7253

Because fish generally have a well developed metabolic capability for detoxication of foreign compounds, and because unsubstituted PAH compounds are particularly labile, the failure to measure tissue residues of these compounds does not mean they were not bioavailable to the fish. Numerous studies have reported high incidences of tumors and lesions in fish from areas of high PAH contamination (Malins et al. 1984, 1987, 1988; Roubal and Malins 1985; Mix et al. 1986). Malins et al. (1984) found consistent positive correlations between the prevalence of hepatic neoplasms and lesions in English sole and sculpin and high concentrations of PAH compounds in sediments of Puget Sound. Similar positive correlations were not found for chlorinated organic compounds. In addition, the cancerous effects were found to be consistent with metabolic studies in organisms exposed to benzo[a]pyrene. More of the ultimate carcinogenic metabolites of benzo[a]pyrene (B[a]P-7,8-diol-9,10-epoxides) were produced and greater covalent binding of the metabolites occurred in sole liver than in rat liver, indicating a greater susceptibility of the fish to cancer from PAH exposure. The bioavailability of these compounds to flatfish from contaminated sediments, and the metabolic disposition that follows has been amply demonstrated in the laboratory using radiotracer techniques (Stein, Hom, and Varanasi 1984; Stein et al. 1987). Exposure of various species of fish in the laboratory to PAH compounds that are known human or other mammalian carcinogens, e.g., benzo[a]pyrene and 7,12-dimethylbenz[a]anthracene, has been demonstrated to cause the development of cancers similar to those observed in fish collected from contaminated areas (Black, Maccubbin, and Johnston 1988; Metcalfe, Cairns, and Fitzsimmons 1988; Hawkins et al. 1989).

PAHs in bivalve mollusks. Although bivalve mollusks are not devoid of the ability to metabolize PAH compounds, their ability to do so is much less than that of fish and other vertebrate organisms. Consequently, most bivalves will bioaccumulate PAHs as the parent compound, and do not as readily show the same toxic effects (tumors, lesions, tissue death and necrosis, etc.) caused by reactive metabolites of PAH compounds and typically seen in fish exposed to these compounds. *Mytilus galloprovincialis* and *M. edulis* exposed in the laboratory to PAHs showed increases in cytochrome P-450 content and NADPH cytochrome c reductase activity but did not show a concomitant increase in benzo[a]pyrene hydroxylase activity (Gilewicz et al. 1984, Livingstone and Farrar 1985, Livingstone et al. 1986). Stegeman (1985) reported benzo[a]pyrene hydroxylase activity in *M. edulis*, but the results were inconsistent, appeared to be seasonal, and were thought to possibly involve other catalytic processes. Evidently, although the bivalves possess a monooxygenase or mixed function oxidase oxidative metabolic biotransformation system, the system does not include the enzymes required for metabolism of PAH compounds to an appreciable extent.

Effect of feeding type. Several laboratory studies have been reported in which both suspension feeding and deposit feeding bivalve mollusks have been exposed to radiolabeled PAH compounds dosed in sediments, water, and food (Roesijadi, Anderson, and Blaylock 1978; Augenfeld and

Anderson 1982; Fortner and Sick 1985; Foster, Baksi, and Means 1987). PAH compounds were readily bioaccumulated by all routes of administration; rates and levels achieved generally related to relative hydrophobicity, similar to the chlorinated hydrocarbons. Comparisons of feeding types showed deposit feeders bioaccumulating to higher levels than suspension feeders (Roesijadi, Anderson, and Blaylock 1978). These authors did not find naphthalene bioaccumulating in *Protothaca staminea*, whereas more hydrophobic alkylated naphthalenes showed detectable amounts in this filter-feeding clam after 60 days. The deposit-feeding clam, *Macoma inquinata*, readily bioaccumulated all PAH compounds. Similar results were obtained by Foster, Baksi, and Means (1987) with another filter-feeding clam, *Mya arenaria*, and a deposit-feeder, *Macoma balthica*.

In the present study, the suspension-feeding mussel (*M. edulis*) frequently bioaccumulated individual PAH compounds to nearly the same level, and in some cases to higher levels, than the deposit feeding clam (*M. nasuta*) (Table 18). These results indicate clearly that, given similar lipoidicities, far more than feeding-type is involved as a determinant of potential for bioaccumulation. Rather, the influence of feeding-type is relevant only with reference to the contaminant fugacity in the contaminant source. In the experiments described here, high and constant levels of contaminated sediments suspended in the water column provided *M. nasuta* with virtually the same exposure as did the same material when it was bedded. This is evident by comparing the results for totals of the 17 PAH compounds analyzed in the Reference and Hot bedded and suspended exposures. Concentrations were nearly identical for *M. nasuta* in the two modes of exposure (29.5 and 27.4 ng/g in Reference; 6743 and 7253 ng/g in Hot BS and S50, respectively). Clearly, the ability of *M. nasuta* to both filter- and deposit feed provided it with equivalent exposures. By contrast, the mussel experienced a five-fold greater bioaccumulation from the suspended Hot material than from the bedded, which must desorb PAH to the overlying water in order for these compounds to be available for uptake. The trend was similar in the Reference sediment, but of lesser magnitude, and represented only a few of the PAH compounds.

Naphthalene, acenaphthene, acenaphthylene. These three compounds (Figure 14) share the same fused two-phenyl ring nucleus (i.e., naphthalene). In addition, acenaphthene and acenaphthylene have a two-carbon bridge across the phenyls, forming a third ring. The more saturated compound, acenaphthene, has the lowest water solubility of the three, and although slightly less planar, would be expected to bioconcentrate to higher levels in the absence of metabolism. Of the three, only acenaphthene has shown mutagenicity in the Ames Test (cited in Verschueren 1983). Naphthalene did not bioaccumulate to significant levels in either bivalve under any conditions of exposure to OHDP Hot or Reference sediments. *M. edulis* bioaccumulated 6.12-11.1 ng/g acenaphthene and/or acenaphthylene from bedded and suspended Hot sediments, and *M. nasuta* bioaccumulated acenaphthene in both Hot sediment exposures to a high of 53.2 ng/g from the bedded sediment. In benthic mollusks and polychaetes collected in sediment grab samples taken on the continental shelf at the New York Bight MDRS, naphthalene was measured at similar concentrations (20.6-30.7 ng/g) in all species, regardless of taxa or lipid content. Acenaphthylene was found only in mollusks (*Nucula* sp., *Yoldia limatula*, and combined Mollusca) at concentrations ranging from 3.62 to 7.06 ng/g, and acenaphthene was found only in *Nucula* sp. at 19 ng/g. The area in which these organisms were collected is considered relatively uncontaminated, although not pristine, and is used as the source of reference sediments for Green Book dredged sediment assessments by the USAE District, New York. Although the bivalves exposed to acenaphthene and acenaphthylene in the OHDP Hot sediments accumulated these compounds to higher levels than the New York Bight MDRS organisms, the difference was only a factor of about two.

Phenanthrene and anthracene. Phenanthrene and anthracene (Figure 15) are three-ring planar PAH isomers, but have differences in their physicochemical properties that affect bioavailability. The water solubility of phenanthrene is 17-20 times greater than that of anthracene, and the log K_{oc} of phenanthrene is 4.08, whereas the log K_{oc} of anthracene is 4.20 (Karickhoff 1981). These characteristics make phenanthrene relatively more bioavailable to aquatic biota than is anthracene. Phenanthrene and anthracene bioaccumulated in bivalves only from the Hot sediment. Mussels bioaccumulated both PAH compounds to approximately three-fold higher levels from suspended than from bedded sediment, and the clams bioaccumulated to essentially the same concentrations from both types of exposure. Twenty-eight day tissue residues of phenanthrene in *M. nasuta* were 634 and 610 ng/g phenanthrene, and 237 and 216 ng/g anthracene, respectively, in the bedded and suspended Hot sediment exposures. Mussels bioaccumulated 49.5 and 138 ng/g phenanthrene and 13.8 and 42.5 ng/g anthracene in the bedded and suspended exposures.

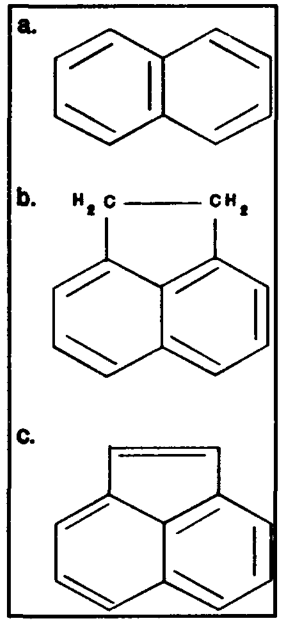

Figure 14.
a. Naphthalene
b. Acenaphthene
c. Acenaphthylene

Field bioaccumulation data from various sources for six PAH compounds and total PAHs in oysters[1], and laboratory bioaccumulation data in mussels are shown in Table 19. By comparison with the data of Table 18, it can be seen that the Hot sediment produced high relative bioaccumulation of phenanthrene in both mussels and clams. Concentrations of phenanthrene are higher in the Hot sediment exposures than concentrations bioaccumulated by mussels exposed to Black Rock Harbor sediments (considered highly contaminated), and approach concentrations in oysters exposed in the field at White Shoals on the James River. Phenanthrene is not carcinogenic or mutagenic, and does not have high acute toxicity to most aquatic organisms. The LC_{50}s for saltwater organisms were reported to range 21.9 to 600 μg/L (Hanson et al. 1991c). The only molluscan species included in that survey was the marine snail, *Nassarius obsoletus*, with an LC_{50} >245 μg/L. The median tolerance limit for phenanthrene to the polychaete *Neanthes (Neries) arenaceodentata* is 600 μg/L in seawater (Rossi and Neff 1978). The LC_{50} in sediment to the amphipod, *Hyallela azteca*, was recently measured at 660 mg/Kg[2]. Fewer toxicity data were found for anthracene. However, anthracene is also reported to be noncarcinogenic and nonmutagenic in the Ames Test (Verschueren 1983). No acute toxicity data were found for anthracene, but the 24-hr no effect level to trout was reported at 5 mg/L.

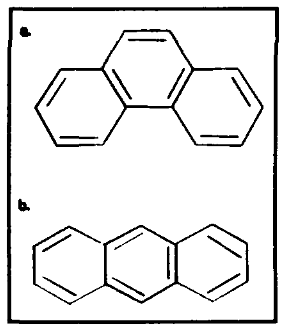

Figure 15.
a. Phenanthrene
b. Anthracene

In field studies at the New York Bight MDRS, phenanthrene was found in all taxa at concentrations ranging from 8.18 ng/g (*Mercenaria* sp.) to 90.5 ng/g (*Nucula* sp.). Anthracene was found in

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[1] Sources of the data for oysters can be found in Pittinger et al. (1985).

[2] Unpublished data, Aquatic Contaminants Team, Environmental Processes and Effects Division, Environmental Laboratory, USAE Waterways Experiment Station.

Table 19
Comparison of PAH Concentrations Reported in Oysters or Mussels at Different Locations[1]. Data Converted to ng/g, Wet Weight

Location	Phe[2]	Fla[3]	Pyr[4]	BaA, Chry[5]	BF[6]	BaP[7]	Total PAH
Wreck Shoals, James R.[8]	0	160	96	0	112	NR	368
Deepwater Shoals, James R.[8]	64	0	0	0	0	0	64
White Shoals, James R.[8]	160	0	0	0	0	0	160
Hospital Pt., Elizabeth R.[8] Hospital Pt., Nor-	16	272	48	96	160	32	624
folk, VA[8]	2.88	NR[9]	32	96	106	0	237
Hospital Pt., Norfolk VA[8]	14.4	74	83	162	157	62	552
Norfolk Harbor VA[8]	NR	2000	320	100	24	12	2456
Chincoteague, VA[8]	NR	NR	0.96	0.16	NR	0.32	1.[illegible]
Long Island Sound, NY[8]	11	NR	116	16	NR	4	136
Galveston Bay, TX[8]	NR	22	21	3.2	6.4	NR	64
Aransas Bay, TX[8]	NR	2.7	1.6	0.96	0.80	NR	6.1
Osaka Port, Japan[8]	NR	NR	104	20	50	5.28	179
Long Island Sound, NY[10]	1.02	0.98	1.5	0.68	0.61	0.1	5.74
Central Long Island Sound, NY[10]	20.8	112	196	327	143	62.7	995
Black Rock Harbor, CN[10]							

[1]Oyster data adapted from Pittinger et al. (1985), mussel data from Lake, Hoffman and Schimmel (1985). [2]Phenanthrene. [3]Fluoranthene. [4]Pyrene. [5]Benz[a]anthracene and/or Chrysene. [6]Benzofluoranthenes (b,k). [7]Benzo[a]pyrene. [8]Oysters, field data. [9]Not reported. [10]Mussels, *M. edulis*, 28-day laboratory exposures.

four of the seven collected taxa at concentrations from 2.95 ng/g (miscellaneous polychaetes) to 23.93 ng/g wet wt. (*Nucula* sp.).

Fluorene and dibenzothiophene. Fluorene is a three-ring, nearly coplanar, unsaturated PAH that is structurally similar to the S-heterocycle, dibenzothiophene (Figure 16). These compounds bear an isosteric relationship to the nucleus of the polyhalogenated coplanar hydrocarbons that include dioxins, dibenzofurans, and coplanar PCBs. However, lacking chlorine or bromine-atom substitution in the lateral positions of the molecule, they possess none of the toxicity of that class of compounds. The two compounds are similar in terms of water solubility, 1.9 mg/L for fluorene (reported in Verschueren 1983) and 1.47 mg/L for dibenzothiophene (Hassett et al. 1980), both at 25°C. The log K_{ow}s are reported as 4.18 for fluorene (Hansch and Leo 1979) and 4.42 for dibenzothiophene (Ogata et al. 1984). Based on the limited information given in the literature, the two compounds appear to be fairly similar in terms of physicochemical properties influencing bioavailability.

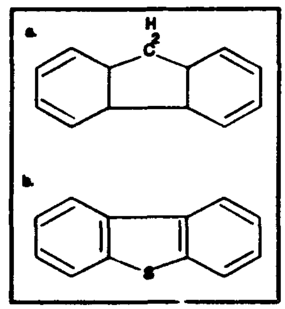

Figure 16.
a. Fluorene
b. Dibenzothiophene

Considering the 330-fold difference in fluorene concentration in the Reference as compared with the Hot sediment, and the relative similarity between the two in terms of organic carbon content, it is noteworthy that *M. nasuta* bioaccumulated to only a 16-fold greater fluorene concentration from the Hot sediment than from the Reference. Boese et al. (in review) suggested that this clam may affect its uptake of bioaccumulating chemicals through a mechanism of particle-size selection in feeding.

The mussels bioaccumulated fluorene and dibenzothiophene only from the Hot sediment. Concentrations of the two compounds in *M. edulis* reached approximately the same levels, ranging from 2.94 to 9.14 ng/g, with higher uptake in the suspended sediment exposures.

Few field data are reported for body burdens in bivalves for these two compounds. Concentrations of fluorene in the estuarine filter-feeding clam, *Rangia cuneata*, transplanted to the vicinity of a creosote spill for up to four weeks ranged from 5 to 63 ng/g wet wt. (DeLeon, Ferraro, and Byrne 1988). In the seven taxa collected at the New York Bight MDRS, fluorene and dibenzothiophene were quantitated only in *Nucula* sp. Concentrations of the two compounds were 18.1 and 7.81 ng/g wet wt., respectively.

Fluoranthene and pyrene. Both compounds are fully aromatic four-ring hydrocarbons (Figure 17). Although structurally dissimilar, the two compounds have similar water solubilities and log K_{ow}s. The solubility of fluoranthene is given as 0.265 mg/L at 25°C, and 0.16 mg/L at 26°C for pyrene (reported in Verschueren 1983). The log K_{ow}s for fluoranthene, biphenyl, and pyrene are summarized in Hanson et al. (1991b) with a single value, 5.155, reported for fluoranthene. Karickhoff (1981) reported a log K_{ow} = 5.18 for pyrene, and the log K_{oc} for that compound was measured at 4.83. These data indicate a similar bioavailability can be expected for the two compounds to aquatic organisms, other factors being equal.

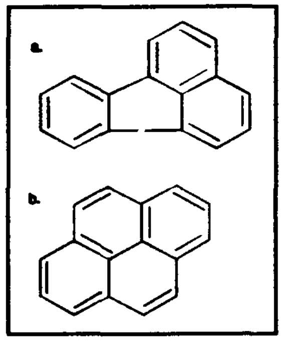

Figure 17.
a. Fluoranthene
b. Pyrene

Clams exposed to bedded and suspended Hot sediment bioaccumulated fluoranthene to very high levels: 1785 and 1871 ng/g, respectively. Mussels exposed to the Hot sediments also bioaccumulated fluoranthene to high levels, particularly from the suspended sediment. Low concentrations (8.92 and 10.3 ng/g) were bioaccumulated by the two bivalves from Reference sediment. Fluoranthene bioaccumulation in the clam from the Hot sediment was of a similar magnitude to concentrations measured in oysters from Norfolk Harbor, VA (Table 19). Mussels bioaccumulated low levels of pyrene from both bedded and suspended Reference sediments. Pyrene concentrations in clams exposed to the Reference sediments were not significantly elevated after 28-day exposures. However, clams exposed to both bedded and suspended Hot sediments bioaccumulated high concentrations of pyrene (1750 and 1958 ng/g), respectively. The OHDP Reference sediment produced negligible pyrene bioaccumulation in the bivalves, whereas the Hot sediment exposures resulted in tissue concentrations on the order of six-fold greater than the highest reported in Table 19 from other areas. Fluoranthene and pyrene were detected in all taxa collected at the New York Bight MDRS. Concentrations were far below those analyzed in bivalves exposed to the Hot sediment, ranging from 7.40 ng/g (*Mercenaria* sp.) to 113.2 ng/g (*Nucula* sp.) for fluoranthene, and from 4.72 ng/g (*Cerebratulus lacteus*) to 101.2 ng/g (*Nucula* sp.) for pyrene.

Benz[a]anthracene and chrysene. These two four-ring PAH compounds (Figure 18) are isomeric with pyrene, but unlike pyrene possess the angular "bay region" that can be acted upon by CYPIA1 monooxygenases to form carcinogenic diol epoxides. Benz[a]anthracene and chrysene are mutagenic in the Ames Test and are considered weak carcinogens to humans (Williams and Weisburger 1987). The log K_{ow} of both isomers is 5.60 calculated from fragment constants (Hansch and Leo 1979). The water solubility reported for chrysene is 0.006 mg/L at 25°C.

A trace level of benz[a]anthracene (2.03 ng/g) was bioaccumulated by mussels from the suspended Reference sediment, and a much higher amount (623 ng/g) was taken up from the suspended Hot sediment. Clams bioaccumulated similar concentrations of benz[a]anthracene (452 and 492 ng/g) from suspended and bedded Hot sediment. Chrysene was bioaccumulated to high levels by both organisms from the Hot sediment. Significant bioaccumulation in mussels occurred only in those organisms exposed to the suspended Hot sediment, and was 925 ng/g at the end of the exposure period. Clams bioaccumulated chrysene from both bedded and suspended Hot sediment exposures to similar levels: 630 and 697 ng/g, respectively. The uptake of chrysene and benz[a]anthracene observed here far exceeds concentrations reported for field-collected organisms in Table 19. The same is true when the data are compared with residues in field-collected organisms from the New York Bight MDRS. Although the two PAH compounds were quantitated in nearly all organisms analyzed, the concentration range for benz[a]-anthracene was only 4.10 (*Mercenaria* sp.) to 52.75 ng/g (*Nucula* sp.); and for chrysene, 4.02 (*Nephtys* sp.) to 60.25 ng/g wet wt. (*Nucula* sp.).

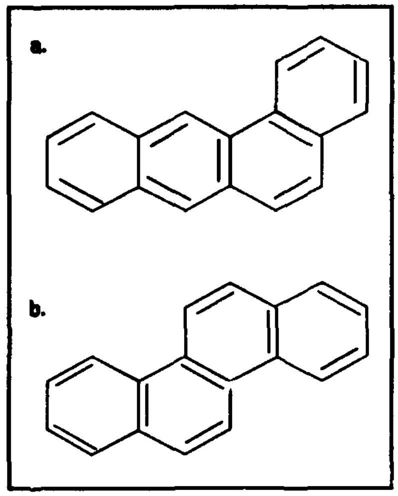

Figure 18.
a. Benz[a]anthracene
b. Chrysene

Benzo[a]pyrene, dibenz[a,h]anthracene, benzo[b]- and benzo[k]fluoranthene. All the members of this group of five-ring PAH compounds are potent human carcinogens. Benzo[a]pyrene and dibenz[a,h]anthracene (Figure 19) are isomers, as are benzo[b]- and benzo[k]fluoranthene (Figure 20). The addition of a benzyl ring to each of these compounds as compared with their four-ring homologues confers greater hydrophobicity and/or forms the angular bay region configuration necessary for bioactivation of the compounds to carcinogenic metabolites (Williams and Weisburger 1987). Benzo[a]pyrene and benzo[b]fluoranthene were bioaccumulated from the Reference sediment by *M. nasuta* to similar levels, ranging from 4.48 to 10.0 ng/g wet wt. with highest concentrations reached in the suspended sediment exposures. Both the clams and the mussels bioaccumulated the two compounds to levels of several hundred ng/g from bedded and suspended Hot sediment, with the highest concentration reached being 872 ng/g benzo[b]fluoranthene in *M. edulis* from suspended material. Benzo[k]fluoranthene bioaccumulated to 407 ng/g in mussels exposed to suspended Hot sediments, and to 204 and 230 ng/g in clams exposed to bedded and suspended Hot sediment, respectively. These levels are generally far in excess of field concentrations reported in Table 19. Field-collected polychaetes and mollusks at the New York Bight MDRS ranged in concentrations of benzo[a]pyrene, benzo[b]fluoranthene, and benzo[k]fluoranthene from < 10 ng/g in *Nephtys* sp., *Cerebratulus lacteus*, and *Mercenaria* sp., to 50 to 90 ng/g for *Nucula* sp., with miscellaneous mollusks and polychaetes intermediate at 10-49 ng/g wet wt. The highest concentration observed was an average of 239 ng/g benzo[k]fluoranthene in the infaunal clam, *Yoldia limatula*.

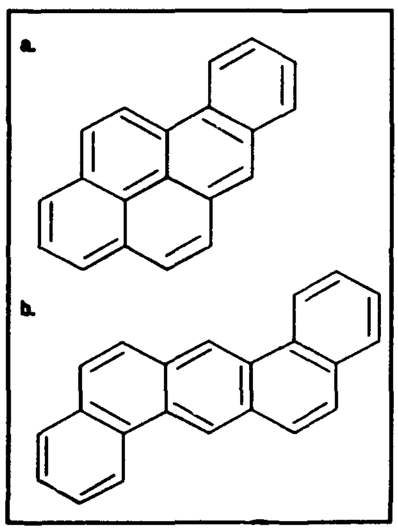

Figure 19.
a. Benzo[a]pyrene
b. Dibenz[a,h]anthracene

The concentrations of dibenz[a,h]anthracene bioaccumulated from the Hot bedded and suspended sediment by mussels (12.2 and 16.7 ng/g) and clams (24.8 and 26.6 ng/g) were comparable to dibenz[a,h]anthracene concentrations in field-collected *Nucula* sp. (20.25 ng/g) and did not greatly exceed concentrations in other taxa at the New York Bight MDRS (2.90-9.71 ng/g).

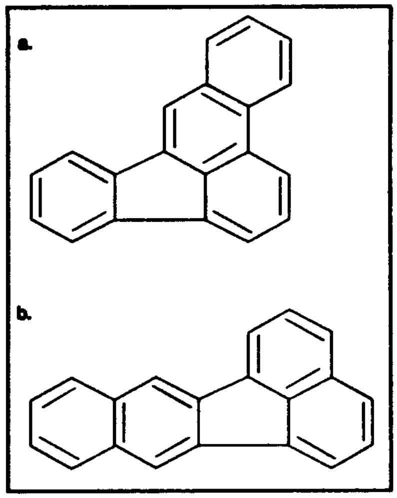

Figure 20.
a. Benzo[b]fluoranthene
b. Benzo[k]fluoranthene

Benzo[g,h,i]perylene and indeno[1,2,3-cd]pyrene. These two six-ring unsubstituted PAH compounds (Figure 21) are the most hydrophobic, and the least studied in terms of toxicity and bioaccumulation. Both compounds were bioaccumulated by *M. nasuta* from bedded and suspended sediment of both the Reference and Hot exposures. Bioaccumulation levels were very similar for the two compounds in all like exposures. Reference sediment-exposed clams bioaccumulated 4.15-5.92 ng/g of each compound. Clams exposed to Hot sediments bioaccumulated 72.0 and 85.3 ng/g indeno[1,2,3-cd]pyrene, and 100 and 117 ng/g benzo[g,h,i]perylene from bedded and suspended sediments, respectively. Mussels bioaccumulated only from the Hot sediment with highest concentrations being reached in the suspended sediment exposures. Mussels bioaccumulated 172 ng/g benzo-[g,h,i]perylene, and 136 ng/g indeno[1,2,3-cd]pyrene. With the exception of *Nucula* sp. at 44-48 ng/g, and *Yoldia limatula* at 16-25 ng/g, concentrations of the two PAH compounds bioaccumulated from the Reference sediment were in the range observed for field-collected organisms at the New York Bight MDRS (1.52-13 ng/g wet wt.).

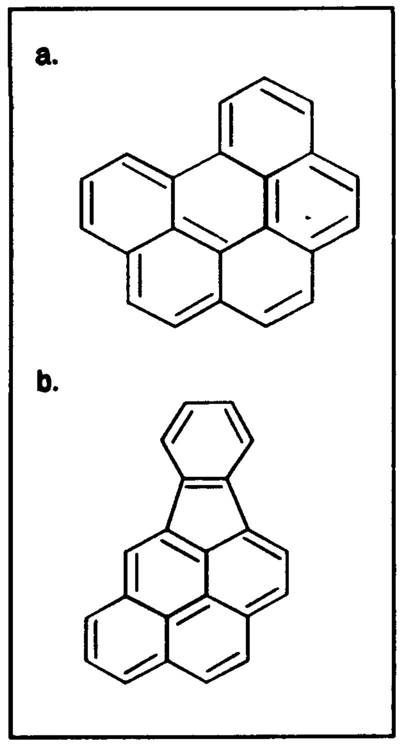

Figure 21.
a. Benzo[g,h,i]perylene
b. Indeno[1,2,3-cd]pyrene

PAH Toxicity to Bivalves. Few toxicity data exist for pyrene. Fluoranthene, however has recently been demonstrated immunotoxic to mammals, suppressing lymphopoesis by causing a rapid induction of DNA fragmentation similar to apoptosis, or programmed cell death (Hinoshita, Hardin, and Sherr 1992). Sediment-associated fluoranthene toxicity to amphipods has been shown to be inversely related to the organic carbon content of sediments, and an interstitial water 10-day LC_{50} of 23.8 μg/L was reported for *Rhepoxynius abronius* (Swartz et al. 1990). Acute toxicities of fluoranthene for saltwater organisms have been reported ranging from 1.6 μg/L for embryonic mysid shrimp, *Mysidopsis bahia*, to >560,000 μg/L for the sheepshead minnow, *Cyprinodon variegatus*. A bivalve mollusk, the coot clam *(Mulinia lateralis)*, was reported to have a fluoranthene LC_{50} of 10,710 μg/L in seawater (Hanson et al. 1991b). The time at which the LC_{50}s were measured was not given.

Toxicities caused by PAHs in bivalves have been related to their effects on lysosomal membranes. Derangement of the lysosomal structure and stability, and associated loss of lysosomal enzyme function in the digestive tract have been observed in *M. edulis* exposed to phenanthrene and anthracene (Moore and Farrar 1985).

A critical concentration threshold was observed for lysosomal effects in mussels exposed to phenanthrene, but for anthracene the effects were linear with concentration in tissues. Major dysfunction occurred with both PAHs at tissue concentrations above 20 μg/g in the laboratory studies. These concentrations are far in excess of anthracene and phenanthrene concentrations bioaccumulated in the two bivalves from either Reference or Hot sediments in the present study. However, effects on membranes of PAH compounds are more likely due to the molar concentration of total PAH compounds and less dependent on concentration of a specific compound. This inference is based on the results of numerous studies in membrane fluidity that have demonstrated the ability of lipophilic chemicals to disrupt the function of membrane-bound enzymes (Gennis 1989). The total concentration of the 17 PAH compounds analyzed in clams and mussels exposed to the Hot sediment ranged from 1,194 to 7,253 ng/g (1.2-7.3 μg/g). In a population of bivalves chronically exposed to the Hot sediment, it is likely that lysosomal toxicities would result. However, bioaccumulation from the Reference sediment does not approach these concentrations, and the PAHs were not detected in the tissues of organisms exposed to the OHDP Inner and Outer sediments. Thus, no potential PAH toxicity to bivalves is indicated for the Reference, Inner, or Outer sediments.

PCBs

Statistically significant increases in polychlorinated biphenyls after 28-day exposures were quantitated only in tissues of mussels exposed to the Reference and Hot sediments. All organisms bioaccumulated some individual congeners over background concentrations in trace quantities (Table 20). PCBs as the mixture A1254 were quantitated only in mussels exposed to the Hot sediment, with highest bioaccumulation, 95.5 ng/g, occurring in the suspended sediment exposures. This concentration is far below the FDA Action Level for PCBs of 2.0 μg/g in fish flesh, and is less than one-fifth the National Academy of Sciences Predator Protection Level for Marine Wildlife of 0.5 μg/g (Mearns et al. 1988).

None of the non-*ortho*- or mono-*ortho*-substituted coplanar PCB congeners were unequivocally identified in any tissue samples. This group of congeners contains the most dioxin-like members of the 209 individual PCBs, and is considered responsible for most, if not all, PCB toxicities. One hexachlorobiphenyl (PCB 128) that is di-*ortho*-substituted and is included among those that warrant concern in environmental samples (McFarland and Clarke 1989), was bioaccumulated to low levels by mussels in both the bedded and suspended Hot sediment exposures, and to an even lower level by clams in the bedded Hot sediment exposures. Concentrations measured were 1.20 and 1.07 ng/g, respectively in the mussels, and 0.692 ng/g in the clams. A dioxin toxicity equivalency factor (TEF) equal to 0.00002 was suggested for the di-*ortho*-substituted PCBs (Safe 1990). Applying this TEF, the mussels exposed to the bedded Hot sediment bioaccumulated the toxic equivalent of 0.024 pg/g 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD). This concentration would be considered insignificant by any comparisons that could presently be made. For example, the early life stages of fish are considered highly sensitive to dioxins and related compounds, including the coplanar PCBs. The no observed adverse effect level for mortality caused by 2,3,7,8-TCDD in lake trout determined at the end of the sac fry stage was reported as 35 pg/g (Cook et al. 1991). This is approximately a 1500-fold higher concentration than was measured in the mussels exposed to Hot bedded sediments. On this basis the PCB bioaccumulation observed here appears inconsequential.

Table 20
Significant Bioaccumulation of PCBs. Tissue Concentrations at Day 28, ng/g Wet Weight

Organism	Reference BS[1]	Reference S50[2]	Hot BS	Hot S50	Reference BS	Reference S50	Hot BS	Hot S50
	A1254				**PCB 32 + 16**			
M. edulis	*[3]	*	70.6	95.5	*	*	3.32	2.15
C. stigmaeus	*	*	*	*	*	*	*	*
M. nasuta	*	*	*	*	*	*	0.775	*
	PCB 8 + 5				**PCB 40**			
M. edulis	*	*	*	*	*	*	2.71	3.17
C. stigmaeus	*	*	*	*	*	*	*	*
M. nasuta	*	*	4.37	*	*	*	0.775	*
	PCB 18				**PCB 44**			
M. edulis	2.70	*	1.67	*	*	*	3.00	3.17
C. stigmaeus	*	*	*	*	*	*	*	*
M. nasuta	*	*	*	*	*	*	2.43	*
	PCB 22				**PCB 45**			
M. edulis	*	*	4.05	4.35	*	*	2.58	*
C. stigmaeus	*	*	*	*	*	*	*	3.35
M. nasuta	*	*	8.85	7.32	*	*	*	*
	PCB 25				**PCB 49 and 48 + 43**			
M. edulis	8.70	7.75	6.38	5.25	*	*	3.43	3.85
C. stigmaeus	*	*	*	*	*	*	2.65	5.33
M. nasuta	1.95	*	3.20	*	*	*	3.18	2.97
	PCB 31 + 28				**PCB 56 + 60**			
M. edulis	*	14.1	*	*	*	*	1.87	2.70
C. stigmaeus	*	*	4.68	7.25	*	*	*	*
M. nasuta	6.08	*	*	*	*	*	2.0	1.24
	PCB 63				**PCB 85**			
M. edulis	8.43	6.37	5.03	*	*	*	4.57	6.10
C. stigmaeus	5.10	*	3.80	*	*	*	6.80	7.90
M. nasuta	*	*	*	*	*	*	2.57	2.63
	PCB 70 + 76				**PCB 87**			
M. edulis	*	*	2.92	4.88	*	*	2.00	2.92
C. stigmaeus	*	*	*	*	*	*	0.892	1.50
M. nasuta	*	*	4.02	3.37	*	*	*	*

[1] Bedded sediment.
[2] 50 mg/L Suspended sediment.
[3] Not detected, or not significant if detected, $P_{\alpha/2} \leq 0.025$.

(Sheet 1 of 3)

Table 20 (Continued)								
	Reference		Hot		Reference		Hot	
Organism	BS[1]	S50[2]	BS	S50	BS	S50	BS	S50
	PCB 74				PCB 91			
M. edulis	*	*	0.925	1.37	*	*	2.18	2.38
C. stigmaeus	*	0.525	*	*	*	*	*	*
M. nasuta	*	*	*	*	*	*	*	*
	PCB 82				PCB 97			
M. edulis	*	*	0.925	1.37	*	*	1.28	1.42
C. stigmaeus	*	0.525	*	*	*	*	*	*
M. nasuta	*	*	*	*	*	*	*	*
	PCB 83				PCB 99			
M. edulis	*	0.758	0.908	1.52	*	*	1.98	2.55
C. stigmaeus	*	*	*	*	*	*	0.775	1.53
M. nasuta	*	*	*	*	*	*	1.40	1.25
	PCB 84 and 92 + 84				PCB 100			
M. edulis	*	*	*	2.80	*	*	*	*
C. stigmaeus	*	*	*	*	*	*	*	*
M. nasuta	*	*	*	*	*	*	0.900	*
	PCB 101 and 101 + 89				PCB 137 + 176			
M. edulis	*	*	5.62	6.68	*	*	2.00	2.32
C. stigmaeus	*	*	2.45	3.58	*	*	*	*
M. nasuta	*	*	4.97	4.67	*	*	*	*
	PCB 110 and 110 + 77				PCB 141			
M. edulis	*	*	7.92	11.4	*	*	*	*
C. stigmaeus	*	*	2.75	4.85	1.25	*	*	*
M. nasuta	*	*	7.52	7.35	*	*	3.23	*
	PCB 118 and 118 + 149				PCB 149			
M. edulis	*	*	4.60	6.33	*	*	1.58	1.23
C. stigmaeus	*	*	1.88	2.95	*	*	0.633	*
M. nasuta	*	*	3.18	3.27	*	*	1.17	0.800
	PCB 128				PCB 151			
M. edulis	*	*	1.20	1.07	*	*	15.6	12.2
C. stigmaeus	*	*	*	*	*	*	3.87	5.60
M. nasuta	*	*	0.692	*	*	*	*	*
								(Sheet 2 of 3)

Table 20 (Concluded)								
	Reference		Hot		Reference		Hot	
Organism	BS[1]	S50[2]	BS	S50	BS	S50	BS	S50
	PCB 131				PCB 153 + 132 + 105			
M. edulis	*	*	*	1.10	*	*	15.6	12.2
C. stigmaeus	*	*	*	*	*	*	3.87	5.60
M. nasuta	*	*	*	*	*	*	*	*
	PCB 134 + 114				PCB 158			
M. edulis	*	*	3.87	7.57	*	*	1.50	2.33
C. stigmaeus	*	*	*	2.70	*	*	*	*
M. nasuta	0.833	0.900	2.15	1.78	*	*	*	*
	PCB 163 + 138				PCB 187 + 182			
M. edulis	*	*	8.48	9.37	*	*	2.08	1.92
C. stigmaeus	0.700	*	2.97	3.40	*	*	*	*
M. nasuta	1.23	*	6.27	5.40	*	*	1.18	0.783
	PCB 170 + 190				PCB 194			
M. edulis	*	*	3.53	5.97	*	*	*	*
C. stigmaeus	*	*	0.808	1.15	*	*	*	*
M. nasuta	*	*	7.43	6.90	*	*	0.758	*
	PCB 177				PCB 198			
M. edulis	*	*	2.92	3.23	*	*	0.983	0.900
C. stigmaeus	*	*	*	*	*	*	*	*
M. nasuta	*	*	1.35	0.800	*	*	*	*
	PCB 178				PCB 202 + 171			
M. edulis	*	*	*	33.3	*	*	1.30	0.900
C. stigmaeus	*	*	*	*	*	*	*	*
M. nasuta	*	*	*	*	*	*	1.08	0.775
	PCB 183							
M. edulis	*	*	1.28	0.883				
C. stigmaeus	*	*	*	*				
M. nasuta	*	*	*	*				

Theoretical Bioaccumulation Potential, TBP, and Accumulation Factors, AF

TBP is intended to approximate the body burden of a neutral organic chemical that would be expected to result in the tissues of an organism exposed to contaminated sediment if it were possible to achieve true equilibrium with the source of exposure (McFarland 1984). Assumptions in the model include complete bioavailability of contaminants to the organism and no metabolic degradation, change in organism lipid content, or other factors affecting rates of uptake and elimination. Thus, TBP envisages a closed system at rest. It is a thermodynamic model in which corrective terms that consider the influences of kinetic processes are to be added based on an iterative process of estimating and then comparing measured and predicted results. TBP uses an "accumulation factor" which expresses the relationship between concentrations of chemical in organism lipids and sediment organic carbon, as the two phases upon which concentration data can be normalized. The accumulation factor

recommended in the Green Book (AF = 4) was used to calculate TBP for PAHs and PCBs in Tables 21 and 22 as:

$$TBP = 4(C_s/f_{oc})f_{lipid} \quad (1)$$

where C_s is the contaminant concentration in sediment, ppb or ppt, dry wt., f_{oc} is the organic carbon content of the sediment as a decimal fraction, dry wt., and f_{lipid} is the lipid content of the organism as a decimal fraction, wet wt. Using these conventions, TBP is in terms of ppb or ppt, wet wt., in an organism of the stated lipid content.

The default AF

In theory, AFs should not vary greatly from one chemical to another. The Green Book recommends a single value, 4, as the default AF, and does not discuss alternatives. The AF = 4 was chosen as a conservative estimate based on an analysis of field data (Lake, Rubinstein, and Pavignano 1987, Lake et al. 1990). At the time the referenced papers were published, very few other studies had been undertaken to empirically measure AFs in different organisms and under different exposure scenarios. However, the value of an idealized AF based on regression equations obtained in laboratory studies had been calculated as 1.73 when lipids were measured using a hexane extraction procedure (McFarland and Clarke 1986).[1] Expressed on a chloroform/methanol extraction basis for lipids using a conversion factor calculated from data of Randall et al. (1991), the idealized AF is about one-half the above value, i.e., 0.927. Good agreement with the theoretical AF is found in a database consisting of 250 empirically determined AF measurements. The database is predominantly based on PCBs, both as Aroclors and individual congeners, but includes a few measurements for chlorobenzenes, PAHs, and other neutral chemicals. A variety of naturally contaminated fresh and saltwater sediments representing a range of organic carbon content are represented. Various infaunal and epibenthic invertebrates are included, as are fish from a confined disposal site. Lipids of all organisms were extracted using a chloroform/methanol procedure or normalized to that basis[2]. The mean for the AF database is 1.009 (0.059 SE), and the median is 0.650 (25th percentile, 0.39; 75th percentile, 1.37). As the data are skewed, the median is a more accurate value for a generalized AF than is the mean. The median is lower by more than a factor of 6 than the Green Book recommended value (AF = 4) used to calculate TBP, and it appears from this that the Green Book estimation is excessively conservative.

TBP predictability

TBPs calculated from the sediment data using the Green Book recommended AF = 4, and the measured lipid content of the organisms used in this study, are compared with the 28-day tissue concentrations measured for the PAHs and A1254 in bedded (Table 21) and suspended (Table 22) Reference and Hot sediment exposures. TBP overestimates the actual tissue concentration in all cases, and frequently by orders of magnitude. The exaggeration is particularly severe in the Hot

[1] Originally termed a "preference factor," pf, and calculated as the inverse of an AF (McFarland 1984).

[2] Unpublished data. V. A. McFarland, USAE Waterways Experiment Station, Vicksburg, MS 39180.

sediment exposures. Twenty-eight day exposures are not sufficient for organisms to reach steady-state levels of bioaccumulation for many, perhaps most, of the hydrophobic neutral chemicals of concern as chemical contaminants of sediments. However, based on estimations from log K_{ow}s (Connell 1990, Clarke and McFarland 1991) most of the chemicals studied can be expected to approach to within 80 percent or more of steady state within 28 days. It is also a given that some metabolism of PAH compounds occurs, even in the bivalves. The PAH compounds are metabolically labile and their low apparent bioaccumulation may be in part due to the fact that only parent compounds, not metabolites, are analyzed. In the flatfish, which has a much greater ability to metabolize most PAH compounds than have either of the bivalves, many of the PAHs could not be detected or were present only in very low concentrations. Also, differential bioavailability is expected for the organisms and for the mode of exposure. For example, chemicals in bedded sediments can be expected to be less bioavailable to mussels, which must be exposed through the water column, and this is indeed the case. Because of differences such as these, the default AF = 4 recommended in the Green Book appears to have very little predictive capability.

Empirical AFs

An alternative for estimation of TBP from sediment data is the use of either laboratory or field-derived AFs based on chemicals, organisms, and exposure concentrations in the calculation. Empirical AFs were calculated for the Reference and Hot sediments and organisms, and these are also given in Tables 21 and 22 for the three species, and for each condition of exposure. In addition, Table 23 combines the suspended and bedded data, and presents AFs calculated for each species, for the bivalves combined, and for all three species combined. Empirical AFs were calculated as:

$$AF = (C_t/f_{lipid})/(C_s/f_{oc}) \qquad (2)$$

where C_t is the concentration of a contaminant in a given organism in ppb or parts per trillion (ppt) on a wet wt. basis, and the other parameters are as defined for equation 1.

It is immediately obvious that the empirical AFs are in all cases much less than the Green Book default AF = 4, and that there are consistent differences for specific chemicals between organisms and exposures. In nearly all cases, the AFs calculated for Hot sediments are lower than AFs calculated for Reference sediments. The implication is that bioavailability from the highly contaminated Hot sediment is less and is not in linear proportion to bioavailability from the less contaminated surficial Reference sediment taken from Central SF Bay.

When these data were analyzed statistically, the mean AF for the Reference sediment was 0.254 (0.048 SE), and the mean AF for the Hot sediment was 0.043 (0.005 SE). However, the data are skewed toward the low end in both data sets, and the median may be a truer indicator of central tendency. The medians are nearly equal: 0.026 (Reference sediment) and 0.027 (Hot sediment). These values are much less than either the idealized AF = 0.927 or the median AF = 0.65 from the AF database.

Individual PAH AFs from the Reference sediment exposures approach these higher values. For example, AFs for naphthalene and phenanthrene in fish exposed to the bedded Reference sediment are 0.883 and 0.558. It is known that fish do not metabolize naphthalene or phenanthrene to an appreciable extent, and that the two- and three-ring PAHs will bioaccumulate to steady-state levels

within 28 days (McCarthy and Jimenez 1985; Foster, Baksi, and Means 1987). We can infer that non-metabolism may also be the case from the similar AFs (0.944 and 0.732) for the other three-ring PAHs, fluorene and acenaphthene respectively, although this was not measured. Additionally, the lipid extractions were done using methylene chloride, and a reliable comparison of extraction efficiencies between methylene chloride and chloroform/methanol or other lipid extraction methods is not currently available. Thus, the calculated AFs may be either somewhat higher or lower than would be the case had another lipid method been used.

Table 24 contains AF data for seven taxa and the sediments from which they were collected at the New York Bight MDRS in a field study recently conducted for the USAE District, New York (McFarland, Lutz, and Reilly in review). The sediments at the New York Bight MDRS contained only 0.5 percent TOC (about one-half that of the Reference and Hot sediments), and concentrations of PAHs and PCBs in the sediments were much nearer those in the Reference sediment and organisms than in the Hot. Summary statistics on the New York Bight MDRS data show a similar skew toward the low values with a mean of 0.136 (0.058 SE) and a median of 0.011. Methylene chloride was used in the lipid determinations similarly to the OHDP Reference and Hot sediment-exposed organisms.

For the higher molecular weight PAHs in general, it appears likely that the low values calculated for empirical AFs may be the result of (1) high strength of sorption to particulates, and/or (2) metabolism, and (3) failure to reach steady-state bioaccumulation levels in the 28-day exposures. The lower AFs for the PAHs as compared with the AFs of the predominantly PCB-derived database are consistent with results of two previous studies reported involving PAH AFs calculated for *M. nasuta*, and *M. edulis*. In both studies PAH AFs were intermediate between the AFs for PCBs reported by Lake, Rubinstein and Pavignano (1987) and Lake et al. (1990) on which the Green Book default AF = 4 is based, and the AFs for PAHs calculated from data of the New York Bight MDRS field study. Ferraro et al. (1990) reported AFs for pyrene, chrysene, benzo[a]pyrene, benz[a]anthracene, and benzo[b+k]fluoranthene ranging 0.05-1.02. Exposures were to bedded sediment in the laboratory for 28 days, and the sediments ranged 0.86-7.37% TOC. Sediment PAH concentrations ranged 1.4-186 ng g^{-1}. Parkerton et al. (1993) used data reported by Broman et al. (1990) for PAHs in seston and *M. edulis* to calculate AFs which ranged 0.02-0.46. Organic carbon content of the seston was reported as 26.8% based on loss on ignition. Although somewhat higher, AFs of both studies are near the PAH AFs calculated for the New York Bight MDRS field study, and are very near PAH AFs calculated in the 28-day OHDP Reference and Hot exposures. It is clear from both results of the laboratory evaluations reported here, and from comparisons with AF data of the New York Bight MDRS field study, and data in the published literature, that the use of empirically obtained AFs in the Green Book TBP calculation can have far greater predictive value than use of the currently recommended Green Book default AF = 4.

Table 21
Theoretical Bioaccumulation Potential (TBP), Accumulation Factors (AF), and 28-day Tissue Concentrations in Organisms Exposed to Bedded Reference and Hot Sediments

Reference Sediment		Mussels, bedded Lipid = 0.022950			Clams, bedded Lipid = 0.014670			Fish, bedded Lipid = 0.010640		
Chemical Name	Sediment ng/g	TBP	AF	Ct ng/g	TBP	AF	Ct ng/g	TBP	AF	Ct ng/g
Acenaphthene	1.62	16	0.191	0.77	10	0.436	1.12	7	0.732	1.36
Acenaphthylene	5.292				34	0.013	0.11	24		
Anthracene	27.33	271	0.013	0.88	173	0.017	0.73	126		
Benz[a]anthracene	115.77	1148	0.002	0.65	734	0.028	5.17	532	0.002	0.25
Benzo[a]pyrene	193.32	1916		0.21	1225	0.015	4.48	889	0.001	0.22
Benzo[b+k]fluoranthene	223.11	2212	0.004	2.35	1414	0.028	9.92	1025		
Benzo[ghi]perylene	128.08	1270	0.003	0.80	812	0.022	4.54	589	0.001	0.09
Chrysene	105.58	1047	0.012	3.19	669	0.025	4.25	485		
Dibenz[a,h]anthracene	5.092	50			32	0.080	0.64	23		
Fluoranthene	242.25	2402	0.010	6.08	1535	0.023	8.92	1113		
Fluorene	1.62	16	0.566	2.27	10	2.057	5.28	7	0.944	1.76
Indeno[123cd]pyrene	127.18	1261	0.002	0.54	806	0.021	4.15	584		
Naphthalene	19.208	190	1.024	48.73	122	1.293	39.34	88	0.883	19.49
Phenanthrene	11.45	114	0.880	24.98	73	1.114	20.20	53	0.558	7.34
Pyrene	251.72	2495	0.012	7.19	1595	0.022	8.81	1157		

(Continued)

Table 21 (Concluded)

Hot Sediment		Mussels, bedded Lipid = 0.015			Clams, bedded Lipid = 0.030			Fish, bedded Lipid = 0.012		
Chemical Name	Sediment ng/g	TBP	AF	Ct ng/g	TBP	AF	Ct ng/g	TBP	AF	Ct ng/g
Acenaphthene	1238.76	6678	0.003	5.33	13365	0.016	53.17	5285		
Acenaphthylene	69.31	374	0.065	6.12	748	0.002	0.45	296		
Anthracene	1766.12	952	0.006	13.78	19055	0.050	236.83	7535	0.001	2.50
Benz[a]anthracene	2408.59	12985	0.064	206.67	25987	0.070	451.83	10277	0.002	4.42
Benzo[a]pyrene	4306.25	23215	0.040	234.67	46461	0.028	319.67	18373		2.26
Benzo[b+k]fluoranthene	7368.13	39722	0.056	559.83	79496	0.032	629.17	31437	0.001	10.45
Benzo[ghi]perylene	3260.84	17579	0.017	75.32	35182	0.011	100.12	13913		0.67
Chrysene	3202.56	17265	0.084	360.67	34553	0.073	629.67	13664	0.001	4.42
Dibenz[a,h]anthracene	432.05	2329	0.021	12.23	4661	0.021	24.80	1843		
Fluoranthene	7122.13	38395	0.032	310.67	76842	0.093	1785.00	30388	0.002	12.72
Fluorene	533.77	2878	0.006	4.58	5759	0.022	32.28	2277		
Indeno[123cd]pyrene	3600.52	19410	0.011	51.55	38847	0.007	71.95	15362		1.06
Naphthalene	550.08	2965	0.079	58.53	5935	0.044	65.92	2347	0.091	53.25
Phenanthrene	5053.03	27241	0.007	49.45	54518	0.047	634.17	21560	0.006	29.92
Pyrene	7329.70	39514	0.030	294.17	79081	0.089	1750.00	31273	0.002	11.78
A1254	475.88	2565	0.110	70.58	5134					

Table 22
Theoretical Bioaccumulation Potential (TBP), Accumulation Factors (AF), and 28-day Tissue Concentrations in Organisms Exposed to Suspended Reference and Hot Sediments

Reference Sediment		Mussels, suspended Lipid = 0.021			Clams, suspended Lipid = 0.012			Fish, suspended Lipid = 0.011		
Chemical Name	Sediment ng/g	TBP	AF	Ct ng/g	TBP	AF	Ct ng/g	TBP	AF	Ct ng/g
Acenaphthene	1.62	15	0.448	1.65	9	0.438	0.93	8	0.246	0.481
Acenaphthylene	5.292				28	0.045	0.31			
Anthracene	27.33	249	0.040	2.50	144	0.012	0.42			
Benz[a]anthracene	115.77	1055	0.008	2.031	608	0.026	4.03	560	0.003	0.36
Benzo[a]pyrene	193.32	1761	0.001	0.58	1015	0.021	5.26	934		0.10
Benzo[b+k]fluoranthene	223.11	2033	0.007	3.64	1172	0.040	11.80			
Benzo[ghi]perylene	128.08	1167	0.002	0.47	673	0.035	5.91	619	0.001	0.221
Chrysene	105.58	962	0.019	4.51	555	0.038	5.26			
Dibenz[a,h]anthracene	5.092	46			27	0.089	0.59			
Fluoranthene	242.25	2207	0.019	10.32	1272	0.041	13.03			
Fluorene	1.62	15	0.887	3.27	9	0.939	2.00	8	0.205	0.40
Indeno[123cd]pyrene	127.16	1158	0.001	0.31	668	0.025	4.22			
Naphthalene	19.208	175	1.009	44.13	101	0.580	14.63	93	0.595	13.82
Phenanthrene	11.45	104	1.173	30.6	60	.588	8.84	55	0.467	6.46
Pyrene	251.72	2293	0.028	16	322	0.042	13.75			

(Continued)

Table 22 (Concluded)

Hot Sediment		Mussels, suspended Lipid = 0.016			Clams, suspended Lipid = 0.03			Fish, suspended Lipid = 0.014		
Chemical Name	Sediment ng/g	TBP	AF	Ct ng/g	TBP	AF	Ct ng/g	TBP	AF	Ct ng/g
Acenaphthene	1238.76	7303	0.005	8.33	13727	0.012	39.60			
Acenaphthylene	69.31	409	0.109	11.13	768	.002	0.37			
Anthracene	1766.12	10412	0.016	42.47	19571	0.044	215.65	8808	0.000	1.00
Benz[a]anthracene	2408.59	14200	0.175	622.50	26690	0.074	491.50	12013	0.004	.11
Benzo[a]pyrene	4306.25	25387	0.097	615.33	47718	0.032	378.83	21477	0.001	5.17
Benzo[b+k]fluoranthene	7368.13	43439	0.118	1278.33	81647	0.035	718.50	36748	0.002	15.96
Benzo[ghi]perylene	3260.84	19224	0.036	171.83	36134	0.013	116.93	16263		0.42
Chrysene	3202.56	18881	.196	924.83	35488	0.079	696.83	15972	0.002	7.59
Dibenz[a,h]anthracene	432.05	2547	0.026	16.71	4788	0.022	26.57	2155		
Fluoranthene	7122.13	41988	0.102	1075.17	78921	0.095	1870.83	35521	0.001	12.94
Fluorene	533.77	3147	0.009	6.77	5915	0.017	24.91	2662		
Indeno[123cd]pyrene	3600.52	21227	0.026	136.00	39898	0.009	85.25	17957		1.18
Naphthalene	550.08	3243	0.071	57.93	6095	.035	53.57	2743	0.118	80.85
Phenanthrene	5053.03	29790	0.018	137.67	55993	0.044	610.17	25201	0.006	36.65
Pyrene	7329.70	43212	0.131	1415.00	81221	0.096	1958.33	36556	0.001	7.33
A1254	475.88	2806	0.136	95.50	5273					

Table 23
Accumulation Factors (AFs) Calculated for OHDP Sediment Data and 28-day Laboratory Bioaccumulation Data

Chemical Name	Mussels	Mussels	Clams	Clams	Fish	Fish	Mussels/ clams	Mussels/ cla. :s	All animals	All animals
	Ref-AF	Hot-AF	Ref-AF	Hot-AF	Ref-AF	Hot-AF	Ref-AF	Hot-AF	Ref-AF	Hot-AF
Acenaphthene	0.319	0.004	0.437	0.014	0.489		0.378	0.009	0.449	0.009
Acenaphthylene		0.087	0.029	0.002			0.029	0.045	0.029	0.045
Anthracene	0.027	0.011	0.014	0.047		0.001	0.020	0.029	0.020	0.023
Benz[a]anthracene	0.005	0.120	0.027	0.072	0.002	0.003	0.016	0.096	0.013	0.077
Benzo[a]pyrene	0.001	0.069	0.018	0.030	0.001	0.001	0.012	0.049	0.009	0.049
Benzo[b+k]fluoranthene	0.006	0.087	0.034	0.033		0.002	0.020	0.060	0.020	0.048
Benzo[ghi]perylene	0.002	0.026	0.029	0.012	0.001		0.015	0.019	0.012	0.019
Chrysene	0.015	0.140	0.032	0.076		0.002	0.024	0.108	0.024	0.086
Dibenz[a,h]anthracene		0.024	0.084	0.022			0.084	0.023	0.084	0.023
Fluoranthene	0.014	0.067	0.032	0.094		0.002	0.023	0.081	0.023	0.065
Fluorene	0.726	0.007	1.498	0.020	0.575		1.112	0.014	1.079	0.014
Indeno[123cd]pyrene	0.001	0.018	0.023	0.008			0.012	0.013	0.012	0.013
Naphthalene	1.016	0.075	0.936	0.040	0.739	0.104	0.976	0.057	0.958	0.064
Phenanthrene	1.027	0.013	0.851	0.045	0.513	0.006	0.939	0.029	0.863	0.024
Pyrene	0.020	0.080	0.032	0.092		0.001	0.026	0.086	0.026	0.069
A1254		0.123						0.123		0.123

Table 24
Accumulation Factors (AFs) Calculated for MDRS Sediments and Organisms. Field Bioaccumulation Study

Chemical Name	Clams	Clams	Worms	Worms	Worms	Worms	Bivalves
	Mercenaria	*Nucula*	*Lumbrineris*	*Nephtys*	*Cerebratulus*	Polychaeta	Mollusca
Acenaphthene		0.023					
Acenaphthylene		0.009					0.001
Anthracene		0.029				0.001	0.001
Benz[a]anthracene	0.023	0.262	0.030			0.009	0.015
Benzo[a]pyrene		0.062	0.011	0.001		0.003	0.004
Benzo[b+k]fluoranthene	0.003	0.085	0.012	0.001	0.004	0.003	0.006
Benzo[ghi]perylene	0.004	0.058	0.008	0.001	0.001	0.003	0.003
Chrysene	0.029	0.299	0.038	0.007	0.004	0.011	0.020
Dibenz[a,h]anthracene		0.025	0.003			0.001	0.001
Fluoranthene	0.039	0.531	0.026	0.007		0.007	0.019
Fluorene		0.085					
Indeno[123cd]pyrene		0.053	0.007	0.001		0.002	0.002
Naphthalene	0.028	0.031	0.025	0.010	0.009	0.008	0.008
Phenanthrene	0.300	2.919	0.257	0.093	0.092	0.077	0.106
Pyrene	0.360	3.731	0.388	0.113	0.047	0.131	0.242
A1254	0.233	0.680	0.254	0.285	0.314	0.134	0.190

6 Conclusions

Based on bulk sediment chemistry of the OHDP Inner, Outer, and Hot sediments and the Berkeley Flats Reference sediment, the following were considered the primary contaminants of concern for analysis of bioaccumulation from these sediments:

a. PAHs: acenaphthene, acenaphthylene, anthracene, benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[g,h,i]perylene, chrysene, dibenz[a,h]anthracene, fluoranthene, fluorene, indeno[1,2,3-cd]pyrene, naphthalene, phenanthrene, and pyrene. Dibenzothiophene, a sulfur-substituted PAH not analyzed in the sediments, was included in the bioaccumulation analyses.

b. Metals: Cd, Cr, and Hg.

c. Organotins: TBT and DBT.

d. PCBs: Aroclor 1254.

e. Chlorinated pesticides: none.

Significant findings with respect to the six bioaccumulation study objectives (Chapter 2) may be summarized as follows:

a. Contaminant concentrations in the New Work depth (-35' to -42' MLLW) OHDP Inner sediment, which was predominantly sand, were generally lower than those in sediments naturally resuspended in the Central Bay, as typified by the Berkeley Flats Reference sediment. Exceptions: Cr and DBT concentrations were significantly higher in the Inner sediment than in the Reference. Contaminant concentrations in the OHDP Outer sediment were generally on a par with those in Reference. By comparison with analyses of sediments from other industrialized estuaries, the Reference sediment was similar to less contaminated, and the Hot similar to highly contaminated surficial sediments. The Inner Harbor New Work sediment was essentially uncontaminated, and the Outer Harbor New Work sediment was, like the Reference, comparable to the sediments at the lower end of the range of contaminants reported in most regions.

b. All analyzed PAHs, as well as Cd, TBT, and Aroclor 1254, were significantly higher, by one to three orders of magnitude, in the demonstrably contaminated sediment (OHDP Hot) than in the OHDP Inner or Outer sediments. Cr concentrations were significantly higher in Inner than in Hot, while Hg was lower in Hot than in the other sediments. Mean DBT concentration was an order of magnitude higher in Hot than in the other sediments, although the differences were not statistically significant.

c. Bioavailability was indicated by significant contaminant bioaccumulation following 28-day exposures to the sediments, compared with initial (Day 0) tissue concentrations of the contaminants. Very few contaminants were bioavailable to indigenous organisms (mussels, clams, and fish) from the OHDP Inner and Outer sediments. Those that were bioavailable included Cr and TBT from Inner, and Cd and Cr from Outer. About half of the PAHs, all three metals and both organotins were demonstrably bioavailable from the Reference sediment, while all of the primary contaminants of concern were bioavailable from the Hot sediment.

d. Following 28-day exposures to the sediments, mussels and clams generally had higher concentrations than fish of all PAHs, Cd, Cr, and the organotins. Fish had higher Hg concentrations than the mollusks following exposure to the Inner and Reference sediments.

e. Most contaminants that bioaccumulated achieved remarkably similar tissue concentrations regardless of whether the exposure was to bedded sediment or 50 mg/L suspended sediment. Exceptions generally involved higher bioaccumulation from suspended sediment than from bedded sediment. In particular, mussels accumulated significantly higher concentrations of PAHs from suspended Hot sediment than from bedded Hot sediment.

f. All PAHs bioaccumulated to a significantly greater extent from Hot than from Reference (PAH bioaccumulation from Inner and Outer could not be included in these analyses because of high detection limits). Highest Cd bioaccumulation occurred from Outer. Relative bioaccumulation from the different sediments was organism-dependent for Cr and Hg. Greater bioaccumulation of TBT and DBT generally occurred from Hot and Reference than from Inner. Aroclor 1254 bioaccumulated to a greater extent from Hot and Outer than from Reference.

g. When sediment neutral organic chemical concentration data were used with the lipid content of the exposed organisms and the Green Book recommended AF = 4 in TBP calculations, the results grossly overestimated the actual bioaccumulation. It is clear that the Green Book recommended AF is excessively conservative. Empirical AFs for the PAHs and A1254 calculated from the data of this study can be used by the SFD, instead of the default AF = 4, in future Tier II bioaccumulation potential estimations. Use of the empirical AFs will substantially improve the accuracy of TBP estimations.

From the above conclusions we summarize that: (*a*) the OHDP Inner Harbor sediments at the New Work depths are relatively uncontaminated and the low levels of contaminants are generally not bioavailable; (*b*) the OHDP Outer Harbor sediments at the New Work depths contain contaminants at levels generally similar to those in the Berkeley Flats Reference sediment, which is representative of the state of contamination of Central SF Bay surficial sediments in general. However, the contaminants in the Outer sediment tend to be less bioavailable than are similar levels of the same contaminants in the Reference sediment; (*c*) the OHDP Hot sediment is indeed highly contaminated, particularly with PAHs, and the contaminants found in Hot are bioavailable to indigenous San Francisco Bay organisms.

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Appendix A

Tables Showing Means, Standard Errors, and Results of All Statistical Comparisons for Sediment and Tissue Concentration Data

Table A1.
Descriptive Statistics and Statistical Comparisons of PAH Concentrations in Oakland Sediments (Inner, Outer, and Hot) and Berkeley Flats Reference Sediment

PAH	Sediment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparison	LSD d_{min}[1]
Acenaphthene (ng/g dry wt.)	Inner	1.800 BC[2]	0.224	5	*t*-tests (log-transformed data)	166
	Outer	8.578 B	0.419	5		
	Hot	1238.762 A	110.877	5		
	Reference	†† 1.620[3] C	0.023	5		
Acenaphthylene (ng/g dry wt.)	Inner	1.340 C	0.157	5	Nonparametric LSD test (data converted to rankits)	17.1
	Outer	6.682 B	0.637	5		
	Hot	69.308 A	10.774	5		
	Reference	† 5.292 B	3.677	5		
Anthracene (ng/g dry wt.)	Inner	3.680 C	0.521	5	LSD test (log-transformed data)	573
	Outer	33.286 B	9.119	5		
	Hot	1766.122 A	382.478	5		
	Reference	27.330 B	4.015	5		
Benz[a]anthracene (ng/g dry wt.)	Inner	19.660 D	1.757	5	LSD test (log-transformed data)	388
	Outer	58.772 C	6.480	5		
	Hot	2408.588 A	258.677	5		
	Reference	115.770 B	9.652	5		
Benzo[a]pyrene (ng/g dry wt.)	Inner	46.800 D	7.517	5	*t*-tests (log-transformed data)	507
	Outer	122.600 C	2.573	5		
	Hot	4306.252 A	337.958	5		
	Reference	193.320 B	16.676	5		
Benzo[b+k]fluoranthene (ng/g dry wt.)	Inner	79.800 C	7.793	5	*t*-tests (log-transformed data)	902
	Outer	193.126 B	4.703	5		
	Hot	7368.134 A	601.617	5		
	Reference	223.110 B	14.503	5		
Benzo[g,h,i]perylene (ng/g dry wt.)	Inner	51.280 C	6.416	5	LSD test (log-transformed data)	459
	Outer	136.872 B	11.059	5		
	Hot	3260.838 A	305.807	5		
	Reference	128.080 B	15.033	5		
Chrysene (ng/g dry wt.)	Inner	21.760 D	2.704	5	LSD test (log-transformed data)	491
	Outer	71.286 C	8.648	5		
	Hot	3203.556 A	327.329	5		
	Reference	105.580 B	8.951	5		
Dibenz[a,h]anthracene (ng/g dry wt.)	Inner	6.660 BC	0.671	5	Nonparametric LSD test (data converted to rankits)	60.4
	Outer	13.234 B	0.564	5		
	Hot	432.046 A	40.148	5		
	Reference	† 5.092 C	3.477	5		

[1] Minimum significant difference that can be detected by LSD test on untransformed data.
[2] For a given contaminant, means followed by the same letter are not significantly different from each other (two-tailed test, $\alpha/2=0.025$).
[3] † Mean includes at least one concentration less than DL and set equal to DL/10;
†† All concentrations less than DL and set equal to DL/10.

(Continued)

Table A1 (Concluded)						
PAH	**Sediment**	**Mean Concentration**	**Standard Error**	**N**	**Test Used for Statistical Comparison**	**LSD d_{min}[1]**
Fluoranthene (ng/g dry wt.)	Inner	28.460 D	2.847	5	LSD test (log-transformed data)	991
	Outer	133.342 C	8.529	5		
	Hot	7122.130 A	660.645	5		
	Reference	242.250 B	17.890	5		
Fluorene (ng/g dry wt.)	Inner	1.660 C	0.175	5	*t*-tests (log-transformed data)	120
	Outer	9.706 B	0.689	5		
	Hot	533.766 A	79.855	5		
	Reference	†† 1.620 C	0.026	5		
Indeno-[1,2,3-cd]pyrene (ng/g dry wt.)	Inner	38.860 C	5.958	5	*t*-tests (log-transformed data)	450
	Outer	125.868 B	2.149	5		
	Hot	3600.520 A	299.696	5		
	Reference	127.160 B	11.669	5		
Naphthalene (ng/g dry wt.)	Inner	3.640 C	0.204	5	Nonparametric *t*-tests (data converted to rankits)	57.4
	Outer	19.860 B	0.507	5		
	Hot	550.076 A	38.020	5		
	Reference	† 19.208 ABC	4.909	5		
Phenanthrene (ng/g dry wt.)	Inner	11.340 D	1.118	5	LSD test (log-transformed data)	689
	Outer	68.326 C	5.461	5		
	Hot	5053.032 A	459.105	5		
	Reference	111.450 B	16.400	5		
Pyrene (ng/g dry wt.)	Inner	45.780 C	4.728	5	LSD test (log-transformed data)	977
	Outer	210.918 B	11.519	5		
	Hot	7329.698 A	651.187	5		
	Reference	251.720 B	18.480	5		

Table A2.
Descriptive Statistics and Statistical Comparisons of Metal Concentrations in Oakland Sediments (Inner, Outer, and Hot) and Berkeley Flats Reference Sediment

Metal	Sediment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparison	LSD d_{min}[1]
Ag (µg/g dry wt.)	Inner	0.077 C[2]	0.005	5	Nonparametric LSD test (data converted to rankits)	0.354
	Outer	0.306 BC	0.067	5		
	Hot	0.839 A	0.077	5		
	Reference	0.562 AB	0.212	5		
As (µg/g dry wt.)	Inner	5.118 B	0.237	5	*t*-tests	3.99
	Outer	8.960 AB	1.546	5		
	Hot	† 6.478[3] AB	2.135	5		
	Reference	10.930 A	0.301	5		
Cd (µg/g dry wt.)	Inner	0.091 D	0.005	5	*t*-tests (log-transformed data)	0.163
	Outer	0.308 B	0.013	5		
	Hot	1.208 A	0.107	5		
	Reference	0.241 C	0.004	5		
Cr (µg/g dry wt.)	Inner	561.200 A	25.043	5	LSD test	62.8
	Outer	286.000 C	14.761	5		
	Hot	450.100 B	29.712	5		
	Reference	194.800 D	5.352	5		
Cu (µg/g dry wt.)	Inner	19.000 D	0.893	5	Nonparametric LSD test (data converted to rankits)	73.9
	Outer	36.760 C	0.497	5		
	Hot	227.820 A	49.303	5		
	Reference	51.470 B	1.200	5		
Hg (µg/g dry wt.)	Inner	0.050 C	0.009	5	*t*-tests (log-transformed data)	0.0324
	Outer	0.583 A	0.007	5		
	Hot	0.005 D	0.001	5		
	Reference	0.351 B	0.019	5		
Ni (µg/g dry wt.)	Inner	62.810 C	1.073	5	LSD test (log-transformed data)	11.8
	Outer	93.040 B	1.703	5		
	Hot	139.320 A	7.469	5		
	Reference	97.600 B	1.550	5		
Pb (µg/g dry wt.)	Inner	10.950 C	0.551	5	Nonparametric LSD test (data converted to rankits)	40.9
	Outer	27.340 B	0.639	5		
	Hot	196.020 A	27.274	5		
	Reference	28.230 B	0.306	5		
Se (µg/g dry wt.)	Inner	0.202 AB	0.012	5	Nonparametric *t*-tests (data converted to rankits)	0.240
	Outer	0.328 A	0.037	5		
	Hot	†† 0.084 B	0.002	5		
	Reference	† 0 .152 B	0.077	5		
Zn (µg/g dry wt.)	Inner	59.040 D	1.192	5	Nonparametric LSD test (data converted to rankits)	58.6
	Outer	106.660 C	0.880	5		
	Hot	341.100 A	39.114	5		
	Reference	117.650 B	0.620	5		

[1] Minimum significant difference that can be detected by LSD test on untransformed data.
[2] For a given contaminant, means followed by the same letter are not significantly different from each other (two-tailed test, $\alpha/2=0.025$).
[3] † Mean includes at least one concentration less than DL and set equal to DL/10;
†† All concentrations less than DL and set equal to DL/10.

Table A3.
Descriptive Statistics and Statistical Comparisons of Pesticide, PCB, and Organotin Concentrations in Oakland Sediments (Inner, Outer, and Hot) and Berkeley Flats Reference Sediment

Contaminant	Sediment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparison	LSD d_{min}[1]
Aldrin (ng/g dry wt.)	Inner	†† 0.300[2] C[3]	0	5	Nonparametric t-tests (data converted to rankits)	2.61
	Outer	2.012 B	0.147	5		
	Hot	9.340 A	1.733	5		
	Reference	†† 0.326 C	0.004	5		
α-BHC (ng/g dry wt.)	Inner	†† 0.300 B	0	5	Nonparametric t-tests (data converted to rankits)	0.360
	Outer	0.500 A	0.084	5		
	Hot	0.940 A	0.225	5		
	Reference	†† 0.326 AB	0.004	5		
4,4'DDD (ng/g dry wt.)	Inner	† 0.300 B	0	5	Nonparametric t-tests (data converted to rankits)	1.23
	Outer	2.724 A	0.342	5		
	Hot	† 2.650 AB	0.747	5		
	Reference	† 0.326 B	0.004	5		
4,4'DDE (ng/g dry wt.)	Inner	†† 0.300 B	0	5	t-tests (log-transformed data)	2.21
	Outer	5.944 A	0.685	5		
	Hot	7.140 A	1.305	5		
	Reference	†† 0.326 B	0.004	5		
4,4'DDT (ng/g dry wt.)	Inner	†† 0.300 AB	0	5	Nonparametric t-tests (data converted to rankits)	1.64
	Outer	† 1.004 AB	0.406	5		
	Hot	†† 0.060 B	0	5		
	Reference	† 1.340 A	1.015	5		
α-Endosulfan (ng/g dry wt.)	Inner	NA[4]	NA	0	t-tests (log-transformed data)	0.800
	Outer	† 0.520 B	0.136	5		
	Hot	4.100 A	0.429	5		
	Reference	†† 0.326 B	0.004	5		
β-Endosulfan (ng/g dry wt.)	Inner	NA	NA	0	Nonparametric t-tests (data converted to rankits)	0.681
	Outer	2.504 A	0.374	5		
	Hot	† 0.280 B	0.080	5		
	Reference	†† 0.326 B	0.004	5		
Dieldrin (ng/g dry wt.)	Inner	NA	NA	0	Nonparametric LSD test (data converted to rankits)	1.98
	Outer	† 0.348 A	0.106	5		
	Hot	† 0.892 A	0.852	5		
	Reference	NA	NA	0		
Lindane (ng/g dry wt.)	Inner	†† 0.300 B	0	5	Nonparametric t-tests (data converted to rankits)	0.632
	Outer	† 0.304 AB	0.080	5		
	Hot	2.764 A	0.414	5		
	Reference	†† 0.326 B	0.004	5		

1 Minimum significant difference that can be detected by LSD test on untransformed data.
2 † Mean includes at least one concentration less than DL and set equal to DL/10;
†† All concentrations less than DL and set equal to DL/10.
3 For a given contaminant, means followed by the same letter are not significantly different from each other (two-tailed test, α/2=0.025).
4 NA = not analyzed.

(Continued)

Table A3 (Concluded)

Contaminant	Sediment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparison	LSD d_{min}[1]
Endrin Aldehyde (ng/g dry wt.)	Inner Outer Hot Reference	†† 0.300 A †† 0.200 A † 1.120 A †† 0.326 A	0 0 0.571 0.004	5 5 5 5	Nonparametric *t*-tests (data converted to rankits)	0.856
Heptachlor Epoxide (ng/g dry wt.)	Inner Outer Hot Reference	†† 0.300 A †† 0.040 A † 0.920 A †† 0.326 A	0 0 0.261 0.004	5 5 5 5	Nonparametric *t*-tests (data converted to rankits)	0.392
Aroclor 1254 (ng/g dry wt.)	Inner Outer Hot Reference	†† 2.600 C 48.620 B 475.884 A †† 3.260 C	0 5.580 13.550 0.040	5 5 5 5	Nonparametric *t*-tests (data converted to rankits)	22.0
TeBT (ng/g dry wt.)	Inner Outer Hot Reference	†† 0.071 A † 1.076 A † 0.812 A †† 0.240 A	0.003 0.602 0.572 0	5 5 5 5	Nonparametric *t*-tests (data converted to rankits)	1.24
TBT (ng/g dry wt.)	Inner Outer Hot Reference	3.460 B † 1.284 C 67.260 A 1.560 BC	0.941 0.401 30.245 0.068	5 5 5 5	LSD test (log-transformed data)	45.4
DBT (ng/g dry wt.)	Inner Outer Hot Reference	2.350 A † 1.113 AB 12.836 AB 1.174 B	0.199 1.022 5.341 0.063	5 5 5 5	*t*-tests (log-transformed data)	8.16
MBT (ng/g dry wt.)	Inner Outer Hot Reference	† 0.442 C 1.837 B 4.680 A †† 0.510 C	0.169 0.313 0.718 0	5 5 5 5	*t*-tests	1.20

Table A4.
Descriptive Statistics of Sediment Conventional Parameters and Statistical Comparisons of Oil and Grease and Total Petroleum Hydrocarbon Concentrations in Oakland Sediments (Inner, Outer, and Hot) and Berkeley Flats Reference Sediment

Parameter	Sediment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparison	LSD d_{min}[1]
Oil and Grease (µg/g dry wt.)	Inner	24.8 C	5.485	5	LSD test (log-transformed data)	137
	Outer	118.4 B	12.906	5		
	Hot	996.0 A[2]	87.755	5		
	Reference	111.8 B	8.176	5		
Total Petroleum Hydrocarbons (µg/g dry wt.)	Inner	38.4 C	6.372	5	*t*-tests (log-transformed data)	104
	Outer	80.8 B	6.583	5		
	Hot	818.0 A	68.220	5		
	Reference	72.0 B	6.611	5		
Moisture (percent)	Inner	22.8	0.457	5	NA[3]	NA
	Outer	47.2	1.960	5		
	Hot	41.4	0.245	5		
	Reference	49.0	1.049	5		
Total Organic Carbon (percent dry wt.)	Inner	0.190	0.005	5	NA	NA
	Outer	0.622	0.012	5		
	Hot	1.110	0.085	5		
	Reference	0.926	0.007	5		
Total Volatile Solids (percent dry wt.)	Inner	2.808	0.089	5	NA	NA
	Outer	3.808	0.114	5		
	Hot	5.748	0.382	5		
	Reference	5.882	0.074	5		
Gravel (percent)	Inner	0.2	0.200	5	NA	NA
	Outer	1.2	0.200	5		
	Hot	2.2	0.490	5		
	Reference	0.4	0.245	5		
Sand (percent)	Inner	69.8	3.652	5	NA	NA
	Outer	36.8	0.200	5		
	Hot	24.8	3.800	5		
	Reference	6.6	0.245	5		
Silt (percent)	Inner	12.4	1.631	5	NA	NA
	Outer	19.6	0.400	5		
	Hot	19.4	0.748	5		
	Reference	45.8	0.374	5		
Clay (percent)	Inner	18.4	1.536	5	NA	NA
	Outer	42.4	0.245	5		
	Hot	53.6	3.669	5		
	Reference	47.4	0.510	5		

[1] Minimum significant difference that can be detected by LSD test on untransformed data.
[2] For a given contaminant, means followed by the same letter are not significantly different from each other (two-tailed test, $\alpha/2=0.025$).
[3] NA = not analyzed.

Table A5.
Oakland Inner Sediment: Descriptive Statistics and Statistical Comparisons of Contaminant Bioaccumulation and Lipid from Bedded Sediment (BS), 50 mg/L Suspended Sediment (S50), and Positive Control (PC) at Day 28, vs. Background (Day 0) Concentrations

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	*N*	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
Cd (µg/g dry wt.)	Mussel	BS	5.191	0.167	6	*t*-tests	1.28
		S50	4.522	0.444	6		
		PC	5.881	0.272	3		
		Day 0	5.996	0.278	3		
	Clam	BS	0.372	0.037	6	*t*-tests	0.191
		S50	0.389	0.056	6		
		PC	0.419	0.073	2		
		Day 0	0.384	0.003	3		
	Fish	BS	0.423	0.023	6	Dunnett's test	0.0789
		S50	0.414	0.017	6		
		PC	0.445	0.014	3		
		Day 0	0.391	0.024	3		
Cr (µg/g dry wt.)	Mussel	BS	1.778 *[2]	0.346	6	Dunnett's test (log-transformed data)	1.17
		S50	1.363 *	0.320	6		
		Day 0	0.308	0.078	3		
	Clam	BS	15.978 *	3.548	6	Dunnett's test (log-transformed data)	9.20
		S50	4.592 *	1.153	6		
		Day 0	0.980	0.272	3		
	Fish	BS	2.368 *	1.054	6	*t*-tests (log-transformed data)	2.61
		S50	0.558	0.112	6		
		Day 0	† 0.069[3]	0.033	3		
Hg (µg/g dry wt.)	Mussel	BS	0.196	0.011	6	*t*-tests	0.061
		S50	0.203	0.021	6		
		Day 0	0.160	0.014	3		
	Clam	BS	0.070	0.010	6	*t*-tests	0.136
		S50	0.171	0.050	6		
		Day 0	0.115	0.048	3		
	Fish	BS	0.396	0.100	6	*t*-tests	0.300
		S50	0.384	0.067	6		
		Day 0	0.365	0.037	3		

[1] Minimum significant difference that can be detected by Dunnett's test on untransformed data.
[2] * Indicates a treatment that is significantly greater than Day 0
** indicates a treatment that is significantly less than Day 0 (two-tailed test, $\alpha/2 = 0.025$).
[3] † Mean includes at least one concentration less than DL and set equal to DL/10;
†† All concentrations less than DL and set equal to DL/10.
Comparisons in which all observations were less than DL are not included in the table.

(Continued)

Table A5 (Concluded)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}*
TBT (ng/g dry wt.)	Mussel	BS S50 Day 0	† 7.230 † 3.602 † 1.515	1.950 2.118 1.215	6 6 3	Dunnett's test (log-transformed data)	7.22
	Clam	BS S50 Day 0	15.275 * † 11.982 †† 0.303	1.886 4.664 0.007	6 6 3	*t*-tests	12.4
	Fish	BS S50 Day 0	† 2.297 †† 0.288 †† 0.322	2.001 0.004 0.009	6 6 3	Nonparametric Dunnett's test (data converted to rankits)	4.93
DBT (ng/g dry wt.)	Mussel	BS S50 Day 0	18.383 14.483 13.900	2.760 2.652 4.110	6 6 3	Dunnett's test	10.5
	Clam	BS S50 Day 0	† 7.222 † 7.980 †† 0.247	3.293 2.629 0.003	6 6 3	*t*-tests	10.4
	Fish	BS S50 Day 0	† 1.348 †† 0.232 †† 0.262	1.110 0.003 0.009	6 6 3	Nonparametric Dunnett's test (data converted to rankits)	2.74
Lipid (percent wet wt.)	Mussel	BS S50 PC Day 0	3.963 1.892 ** 2.370 6.310	0.695 0.278 1.073 0.514	6 6 3 3	*t*-tests	2.33
	Clam	BS S50 PC Day 0	1.315 ** 1.514 0.990 ** 2.833	0.130 0.343 0.070 0.260	6 5 2 3	Nonparametric Dunnett's test (data converted to rankits)	0.988
	Fish	BS S50 PC Day 0	1.423 ** 1.275 ** 1.290 ** 2.740	0.083 0.151 -- 0.165	6 6 1 3	Dunnett's test	0.566

Table A6.
Descriptive Statistics and Statistical Comparisons of Contaminant Bioaccumulation and Lipid in Fish (*Citharichthys stigmaeus*), Clams (*Macoma nasuta*), and Mussels (*Mytilus edulis*) Exposed to Oakland Inner Sediment for 28 Days

Contaminant	Organism	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
As (µg/g wet wt.)	Clam	4.417 A[2]	0.219	9	*t*-tests	0.431
	Mussel	1.552 B	0.087	9		
	Fish	0.615 C	0.103	9		
Cd (µg/g wet wt.)	Mussel	1.244 A	0.092	9	Nonparametric LSD test (data converted to rankits)	0.268
	Clam	0.476 B	0.121	9		
	Fish	0.384 B	0.037	9		
Cd[3] (µg/g dry wt.)	Mussel	5.061 A	0.229	15	Nonparametric *t*-tests (data converted to rankits)	0.374
	Fish	0.424 B	0.011	15		
	Clam	0.386 B	0.028	14		
Cr (µg/g wet wt.)	Clam	1.389 A	0.157	9	LSD test (log-transformed data)	0.302
	Fish	0.730 B	0.083	9		
	Mussel	0.390 C	0.056	9		
Cr[3] (µg/g dry wt.)	Clam	10.285 A	2.472	12	LSD test (log-transformed data)	3.81
	Mussel	1.570 B	0.233	12		
	Fish	1.463 B	0.574	12		
Pb (µg/g wet wt.)	Clam	0.430 A	0.031	9	*t*-tests	0.0691
	Mussel	0.135 B	0.012	9		
	Fish	† 0.073[4] B	0.023	9		
Hg (µg/g wet wt.)	Fish	†† 0.064 AB	0.010	9	Nonparametric *t*-tests (data converted to rankits)	0.0238
	Clam	† 0.017 A	0.010	9		
	Mussel	† 0.006 B	0.0004	9		
Hg[3] (µg/g dry wt.)	Fish	0.390 A	0.057	12	*t*-tests	0.109
	Mussel	0.199 B	0.012	12		
	Clam	0.120 B	0.029	12		
Ni (µg/g wet wt.)	Clam	0.649 A	0.135	9	LSD test (log-transformed data)	0.237
	Mussel	0.539 A	0.068	9		
	Fish	0.219 B	0.028	9		
TBT[3] (ng/g dry wt.)	Clam	† 13.628 A	2.449	12	*t*-tests	4.95
	Mussel	† 5.416 B	1.477	12		
	Fish	† 1.293 B	1.001	12		
DBT[3] (ng/g dry wt.)	Mussel	16.433 A	1.917	12	*t*-tests	4.75
	Clam	† 7.601 B	2.012	12		
	Fish	† 0.790 C	0.555	12		
Lipid (percent wet wt.)	Mussel	2.816 A	0.422	15	*t*-tests (log-transformed data)	1.67
	Fish	1.345 B	0.078	13		
	Clam	1.342 B	0.145	13		

[1] Minimum significant difference that can be detected by LSD test on untransformed data.
[2] For a given contaminant, means followed by the same letter are not significantly different from each other (two-tailed test, $\alpha/2 = 0.025$).
[3] Chemical analysis from a different laboratory.
[4] † Mean includes at least one concentration less than DL and set equal to DL/10;
†† All concentrations less than DL and set equal to DL/10.

Table A7.
Oakland Inner Sediment: Descriptive Statistics and Statistical Comparisons of Contaminant Bioaccumulation and Lipid from 28-Day Exposures to Bedded Sediment (BS) vs. 28-Day Exposures to 50 mg/L Suspended Sediment (S50)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
Cd (µg/g dry wt.)	Mussel	BS S50	5.191 4.522	0.167 0.444	6 6	*t*-test	1.06
	Clam	BS S50	0.372 0.389	0.037 0.056	6 6	*t*-test	0.19
	Fish	BS S50	0.423 0.414	0.023 0.017	6 6	*t*-test	0.064
	All	BS S50	1.995 1.775	0.551 0.492	18 18	Wilcoxon Rank-Sum test	1.50
Cr (µg/g dry wt.)	Mussel	BS S50	1.778 1.363	0.346 0.320	6 6	*t*-test	1.05
	Clam	BS S50	15.978 *[2] 4.592	3.548 1.153	6 6	*t*-test	8.31
	Fish	BS S50	2.368 * 0.558	1.054 0.112	6 6	*t*-test (log-transformed data)	2.36
	All	BS S50	6.708 * 2.171	1.971 0.566	18 18	*t*-test (log-transformed data)	4.17
Hg (µg/g dry wt.)	Mussel	BS S50	0.196 0.203	0.011 0.021	6 6	*t*-test	0.054
	Clam	BS S50	0.070 0.171	0.010 0.050	6 6	*t*-test	0.113
	Fish	BS S50	0.396 0.384	0.100 0.067	6 6	*t*-test	0.268
	All	BS S50	0.221 0.253	0.045 0.035	18 18	*t*-test (log-transformed data)	0.117
TBT (ng/g dry wt.)	Mussel	BS S50	† 7.230[3] † 3.602	1.950 2.118	6 6	*t*-test	6.41
	Clam	BS S50	15.275 † 11.982	1.886 4.664	6 6	*t*-test	11.2
	Fish	BS S50	† 2.297 †† 0.288	2.001 0.005	6 6	Wilcoxon Rank-Sum test	4.46
	All	BS S50	† 8.267 † 5.291	1.672 1.999	18 18	Wilcoxon Rank-Sum test	5.30

[1] Minimum significant difference that can be detected by LSD test on untransformed data.
[2] * Indicates a treatment that is significantly greater than the other treatment (two-tailed test, $\alpha/2 = 0.025$).
[3] † Mean includes at least one concentration less than DL and set equal to DL/10;
†† All concentrations less than DL and set equal to DL/10.

(Continued)

Table A7 (Concluded)							
Contaminant	**Organism**	**Treat-ment**	**Mean Con-centration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**LSD d_{min}[1]**
DBT (ng/g dry wt.)	Mussel	BS S50	18.383 14.483	2.760 2.652	6 6	*t*-test	8.53
	Clam	BS S50	† 7.222 † 7.980	3.293 2.629	6 6	*t*-test	9.39
	Fish	BS S50	† 1.348 †† 0.232	1.110 0.003	6 6	Wilcoxon Rank-Sum test	2.47
	All	BS S50	† 8.984 † 7.565	2.206 1.834	18 18	Wilcoxon Rank-Sum test	5.83
Lipid (% wet wt.)	Mussel	BS S50	3.963 * 1.892	0.695 0.278	6 6	*t*-test	1.67
	Clam	BS S50	1.315 1.514	0.130 0.343	6 5	Wilcoxon Rank-Sum test	5.46
	Fish	BS S50	1.423 1.275	0.083 0.151	6 6	*t*-test	0.383
	All	BS S50	2.234 1.563	0.371 0.155	18 17	Wilcoxon Rank-Sum test	0.835

Table A8.
Oakland Outer Sediment: Descriptive Statistics and Statistical Comparisons of Contaminant Bioaccumulation and Lipid from Bedded Sediment (BS), 50 mg/L Suspended Sediment (S50), and Positive Control (PC) at Day 28, vs. Background (Day 0) Concentrations

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
Aroclor 1242 (µg/g wet wt.)	Clam	BS S50 PC Day 0	†† 0.007[2] †† 0.008 †† 0.007 † 0.329	0.0008 0.0011 0.0002 0.3212	6 5 2 2	Nonparametric *t*-tests (data converted to rankits)	0.267
Aroclor 1254 (µg/g wet wt.)	Clam	BS S50 PC Day 0	† 0.078 † 0.052 †† 0.014 † 0.084	0.0554 0.0272 0.0005 0.0660	6 5 2 2	Nonparametric *t*-tests (data converted to rankits)	0.200
Total PCB (µg/g wet wt.)	Clam	BS S50 PC Day 0	0.198 0.176 † 0.036 0.375	0.105 0.079 0.023 0.245	6 5 2 2	Dunnett's test (log-transformed data)	0.446
PCB 15 (µg/g wet wt.)	Clam	BS S50 PC Day 0	† 0.004 † 0.009 †† 0.002 †† 0.003	0.0018 0.0039 0.0001 0.0002	6 5 2 2	Nonparametric *t*-tests (data converted to rankits)	0.012
PCB 52 (µg/g wet wt.)	Clam	BS S50 PC Day 0	† 0.002 †† 0.002 †† 0.002 † 0.019	0.0003 0.0003 0.0001 0.0169	6 5 2 2	Nonparametric *t*-tests (data converted to rankits)	0.014
PCB 60 (µg/g wet wt.)	Clam	BS S50 PC Day 0	† 0.006 † 0.005 †† 0.002 † 0.018	0.0010 0.0011 0.0001 0.0159	6 5 2 2	*t*-tests (log-transformed data)	0.014
Cd (µg/g dry wt.)	Mussel	BS S50 PC Day 0	8.900 *[3] 9.196 * 29.263 * 5.908	0.899 0.754 1.971 0.343	6 6 3 3	Dunnett's test (log-transformed data)	3.74
	Clam	BS S50 PC Day 0	0.331 0.325 2.004 * 0.264	0.014 0.053 – 0.040	2 3 1 3	*t*-tests	0.244
	Fish	BS S50 PC Day 0	0.589 0.582 0.867 0.642	0.038 0.031 0.015 0.070	5 6 2 3	Nonparametric *t*-tests (data converted to rankits)	0.161

[1] Minimum significant difference that can be detected by Dunnett's test on untransformed data.
[2] † Mean includes at least one concentration less than DL and set equal to DL/10;
†† All concentrations less than DL and set equal to DL/10.
Comparisons in which all observations were less than DL are not included in the table.
[3] * Indicates a treatment that is significantly greater than Day 0
** indicates a treatment that is significantly less than Day 0 (two-tailed test, $\alpha/2 = 0.025$).

(Continued)

Table A8 (Concluded)

Contaminant	Organ-ism	Treat-ment	Mean Concen-tration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
Cr (μg/g dry wt.)	Mussel	BS S50 Day 0	1.548 * 3.253 * 0.440	0.125 0.818 0.085	6 6 3	*t*-tests (log-transformed data)	2.04
	Clam	BS S50 Day 0	3.610 14.000 * 1.057	0.370 8.336 0.273	2 3 3	Dunnett's test (log-transformed data)	24.1
	Fish	BS S50 Day 0	0.518 1.167 0.810	0.057 0.344 0.156	5 6 3	*t*-tests	0.958
Hg (μg/g dry wt.)	Mussel	BS S50 Day 0	0.613 ** 0.576 ** 0.811	0.040 0.029 0.041	6 6 3	Dunnett's test	0.130
	Clam	BS S50 Day 0	0.144 †† 0.0005 ** 0.172	0.029 0 0.008	2 3 3	*t*-tests	0.053
	Fish	BS S50 Day 0	0.370 0.343 0.512	0.031 0.007 0.060	5 6 3	*t*-tests	0.102
Lipid (% wet wt.)	Mussel	BS S50 PC Day 0	1.612 ** 1.712 ** 1.790 ** 3.753	0.213 0.238 0.252 0.032	6 5 3 3	Dunnett's test	0.848
	Clam	BS S50 PC Day 0	1.370 2.523 1.030 1.867	0.220 0.237 – 0.156	2 3 1 3	Nonparametric Dunnett's test (data converted to rankits)	1.08
	Fish	BS S50 PC Day 0	1.320 ** 1.283 ** 1.470 ** 3.740	0.222 0.111 – 0.659	3 6 1 3	Dunnett's test (log-transformed data)	1.34

Table A9.
Descriptive Statistics and Statistical Comparisons of Contaminant Bioaccumulation and Lipid in Fish (*Citharichthys stigmaeus*), Clams (*Macoma nasuta*), and Mussels (*Mytilus edulis*) Exposed to Oakland Outer Sediment for 28 Days

Contaminant	Organism	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
Aroclor 1254 (µg/g wet wt.)	Fish mussel Clam	† 0.9525[2] A[3] † 0.0647 A † 0.0518 B	0.7729 0.0094 0.0236	12 17 15	Nonparametric *t*-tests (data converted to rankits)	1.02
Aroclor 1254[4] (µg/g wet wt.)	Fish mussel Clam	† 0.1827 A † 0.0647 A † 0.0518 B	0.0760 0.0094 0.0236	11 17 15	Nonparametric *t*-tests (data converted to rankits)	0.108
Aroclor 1254[5] (µg/g wet wt.)	Fish mussel Clam	† 0.1807 A † 0.0641 A † 0.0556 A	0.0764 0.0095 0.0232	11 17 15	*t*-tests (log-transformed data)	0.108
Total PCB (µg/g wet wt.)	Fish mussel Clam	† 1.3213 A † 0.1484 B † 0.1477 B	0.9111 0.0182 0.0501	12 17 15	LSD test (log-transformed data)	1.21
Total PCB[4] (µg/g wet wt.)	Fish mussel Clam	† 0.4233 A † 0.1484 AB † 0.1477 B	0.1681 0.0182 0.0501	11 17 15	LSD test (log-transformed data)	0.235
Total PCB[5] (µg/g wet wt.)	Fish Clam mussel	† 0.4213 A † 0.1483 B † 0.1478 AB	0.1685 0.0499 0.0185	11 15 17	LSD test (log-transformed data)	0.235
PCB 15 (µg/g wet wt.)	mussel Fish Clam	† 0.0158 A † 0.0096 A † 0.0063 B	0.0036 0.0040 0.0018	17 12 15	Nonparametric LSD test (data converted to rankits)	0.0092
PCB 15[5] (µg/g wet wt.)	mussel Fish Clam	† 0.0159 A † 0.0096 A † 0.0068 A	0.0036 0.0045 0.0017	17 11 15	Nonparametric *t*-tests (data converted to rankits)	0.0095
PCB 52 (µg/g wet wt.)	mussel Fish Clam	† 0.0088 B † 0.0066 A † 0.0023 B	0.0063 0.0014 0.0002	17 12 15	Nonparametric LSD test (data converted to rankits)	0.0126
PCB 52[5] (µg/g wet wt.)	mussel Fish Clam	† 0.0093 AB † 0.0065 A †† 0.0030 B	0.0063 0.0015 0	17 11 15	Nonparametric *t*-tests (data converted to rankits)	0.0130
PCB 137 (µg/g wet wt.)	Fish mussel Clam	† 0.0133 A †† 0.0024 B †† 0.0022 B	0.0097 0.0002 0.0002	12 17 15	Nonparametric LSD test (data converted to rankits)	0.0126

[1] Minimum significant difference that can be detected by LSD test on untransformed data.
[2] † *Mean includes at least one concentration* less than DL and set equal to DL/10;
†† All concentrations less than DL and set equal to DL/10.
[3] For a given contaminant, means followed by the same letter are not significantly different from each other (two-tailed test, $\alpha/2 = 0.025$).
[4] One outlier deleted (Fish positive control).
[5] One outlier deleted (Fish positive control) and all values < DL/10 set = mean DL/10.

(Continued)

Table A9 (Continued)						
Contaminant	**Organism**	**Mean Concentration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**LSD d_{min}[1]**
PCB 156 (µg/g wet wt.)	Fish Mussel Clam	† 0.0442 A †† 0.0024 B †† 0.0022 B	0.0396 0.0002 0.0002	12 17 15	Nonparametric LSD test (data converted to rankits)	0.0516
PCB 171 (µg/g wet wt.)	Fish Mussel Clam	† 0.0481 A †† 0.0024 B †† 0.0022 B	0.0412 0.0002 0.0002	12 17 15	Nonparametric LSD test (data converted to rankits)	0.0537
PCB 194 (µg/g wet wt.)	Gish Mussel Clam	† 0.0217 A †† 0.0024 B † 0.0022 B	0.0180 0.0002 0.0002	12 17 15	Nonparametric LSD test (data converted to rankits)	0.0234
PCB 196 (µg/g wet wt.)	Fish Mussel Clam	† 0.0200 A †† 0.0024 B †† 0.0022 B	0.0164 0.0002 0.0002	12 17 15	Nonparametric LSD test (data converted to rankits)	0.0212
PCB 203 (µg/g wet wt.)	Fish Mussel Clam	† 0.0192 A †† 0.0024 B † 0.0024 B	0.0155 0.0002 0.0004	12 17 15	Nonparametric LSD test (data converted to rankits)	0.0202
PCB 209 (µg/g wet wt.)	Mussel Clam Fish	† 0.0146 A † 0.0086 A † 0.0077 A	0.0027 0.0025 0.0028	17 15 12	Nonparametric *t*-tests (data converted to rankits)	0.0077
PCB 209[5] (µg/g wet wt.)	Mussel Clam Fish	† 0.0145 A † 0.0091 A † 0.0076 A	0.0028 0.0024 0.0031	17 15 11	Nonparametric *t*-tests (data converted to rankits)	0.0080
PCB congener DL/10 (µg/g wet wt.)	Fish Mussel Clam	0.0036 A 0.0024 B 0.0022 B	0.0002 0.0002 0.0002	12 17 15	Nonparametric LSD test (data converted to rankits)	0.00050
Cd (µg/g dry wt.)	Mussel Fish Clam	13.091 A 0.629 B 0.607 C	2.231 0.035 0.280	15 13 6	Nonparametric LSD test (data converted to rankits)	3.68
Cr (µg/g dry wt.)	Clam Mussel Fish	9.844 A 2.400 B 0.872 C	5.228 0.471 0.208	5 12 11	Nonparametric LSD test (data converted to rankits)	4.48
Hg (µg/g dry wt.)	Mussel Fish Clam	0.594 A 0.355 B † 0.058 C	0.024 0.014 0.036	12 11 5	*t*-tests	0.0642
Lipid (% wet wt.)	Clam Mussel Fish	1.890 A 1.686 A 1.313 A	0.312 0.127 0.088	6 14 10	LSD test (log-transformed data)	0.454

Table A10.
Oakland Outer Sediment: Descriptive Statistics and Statistical Comparisons of Contaminant Bioaccumulation and Lipid from 28-Day Exposures to Bedded Sediment (BS) vs. 28-Day Exposures to 50 mg/L Suspended Sediment (S50)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
Aroclor 1254 (μg/g wet wt.)	Mussel	BS S50	0.0492 0.1002 *[2]	0.0051 0.0178	6 6	*t*-test	0.0412
	Clam	BS S50	† 0.0777[3] † 0.0518	0.0554 0.0272	6 5	Wilcoxon Rank-Sum test	0.149
	Fish	BS S50	0.3073 0.1237	0.1882 0.0596	4 6	Wilcoxon Rank-Sum test	0.384
	All	BS S50	† 0.1244 † 0.0942	0.0540 0.0231	16 17	*t*-test (log-transformed data)	0.117
Total PCB (μg/g wet wt.)	Mussel	BS S50	0.1335 0.2083 *	0.0181 0.0271	6 6	*t*-test	0.073
	Clam	BS S50	0.1983 0.1760	0.1047 0.0794	6 5	*t*-test (log-transformed data)	0.308
	Fish	BS S50	0.6850 0.3128	0.4172 0.1321	4 6	Wilcoxon Rank-Sum test	0.851
	All	BS S50	0.2957 0.2357	0.1163 0.0518	16 17	*t*-test (log-transformed data)	0.255
PCB 15 (μg/g wet wt.)	Mussel	BS S50	† 0.0192 † 0.0204	0.0066 0.0065	6 6	*t*-test	0.0206
	Clam	BS S50	† 0.0040 † 0.0091	0.0018 0.0039	6 5	*t*-test (log-transformed data)	0.0091
	Fish	BS S50	†† 0.0034 † 0.0155	0.0002 0.0076	4 6	Wilcoxon Rank-Sum test	0.0219
	All	BS S50	† 0.0095 † 0.0153	0.0031 0.0037	16 17	Wilcoxon Rank-Sum test	0.0098
PCB 52 (μg/g wet wt.)	Mussel	BS S50	† 0.0204 †† 0.0024	0.0179 0.0003	6 6	Wilcoxon Rank-Sum test	0.0399
	Clam	BS S50	† 0.0024 †† 0.0024	0.0003 0.0003	6 5	*t*-test	0.0010
	Fish	BS S50	† 0.0083 † 0.0062	0.0037 0.0014	4 6	*t*-test	0.0078
	All	BS S50	† 0.0106 † 0.0037	0.0067 0.0007	16 17	Wilcoxon Rank-Sum test	0.0133

[1] Minimum significant difference that can be detected by LSD test on untransformed data.
[2] * Indicates a treatment that is significantly greater than the other treatment (two-tailed test, $\alpha = 0.025$).
[3] † Mean includes at least one concentration less than DL and set equal to DL/10;
†† All concentrations less than DL and set equal to DL/10.

(Sheet 1 of 3)

Table A10 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 209 (µg/g wet wt.)	Mussel	BS S50	† 0.0177 † 0.0116	0.0052 0.0043	6 6	*t*-test	0.0151
	Clam	BS S50	† 0.0080 † 0.0109	0.0049 0.0049	6 5	*t*-test (log-transformed data)	0.0159
	Fish	BS S50	† 0.0148 † 0.0041	0.0077 0.0007	4 6	*t*-test (log-transformed data)	0.0141
	All	BS S50	† 0.0133 † 0.0087	0.0032 0.0021	16 17	*t*-test (log-transformed data)	0.0079
Cd (µg/g dry wt.)	Mussel	BS S50	8.900 9.196	0.899 0.754	6 6	*t*-test	2.61
	Clam	BS S50	0.331 0.325	0.014 0.053	2 3	*t*-test	0.219
	Fish	BS S50	0.589 0.581	0.038 0.031	5 6	Wilcoxon Rank-Sum test	0.109
	All	BS S50	4.385 3.976	1.270 1.175	13 15	Wilcoxon Rank-Sum test	3.55
Cr (µg/g dry wt.)	Mussel	BS S50	1.548 3.253	0.125 0.818	6 6	*t*-test	1.84
	Clam	BS S50	3.610 14.000	0.370 8.336	2 3	*t*-test	34.3
	Fish	BS S50	0.518 1.167	0.057 0.344	5 6	*t*-test	0.868
	All	BS S50	1.469 4.568	0.305 1.936	13 15	*t*-test (log-transformed data)	4.33
Hg (µg/g dry wt.)	Mussel	BS S50	0.613 0.576	0.040 0.029	6 6	*t*-test	0.110
	Clam	BS S50	0.144 †† 0.0005	0.029 0	2 3	*t*-test	0.069
	Fish	BS S50	0.370 0.343	0.031 0.007	5 6	*t*-test	0.066
	All	BS S50	0.447 0.368	0.053 0.058	13 15	*t*-test	0.163

(Sheet 2 of 3)

Table A10 (Concluded)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
Lipid (percent wet wt.)	Mussel	BS S50	1.612 1.712	0.213 0.238	6 5	*t*-test	0.721
	Clam	BS S50	1.370 2.523 *	0.220 0.237	2 3	*t*-test	1.11
	Fish	BS S50	1.320 1.283	0.222 0.111	3 6	*t*-test (log-transformed data)	0.516
	All	BS S50	1.488 1.702	0.133 0.164	11 14	*t*-test	0.456

Table A11.
Berkeley Flats Reference Sediment: Descriptive Statistics and Statistical Comparisons of Contaminant Bioaccumulation and Lipid from Bedded Sediment (BS), 50 mg/L Suspended Sediment (S50), and Positive Control (PC) at Day 28, vs. Background (Day 0) Concentrations

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
Acenaphthene (ng/g wet wt.)	Mussel	BS	†† 0.766[2]	0.078	6	*t*-tests (log-transformed data)	2.88
		S50	† 1.653	0.816	6		
		PC	† 1.101	0.523	3		
		Day 0	† 2.246	1.677	3		
	Clam	BS	† 1.118	0.644	6	Dunnett's test (log-transformed data)	2.11
		S50	† 0.932	0.467	6		
		PC	† 1.309	0.550	3		
		Day 0	†† 0.342	0.084	3		
	Fish	BS	† 1.363	0.741	6	Nonparametric *t*-tests (data converted to rankits)	2.18
		S50	† 0.481	0.160	6		
		PC	†† 0.511	0.089	3		
		Day 0	† 1.118	0.896	3		
Acenaphthylene (ng/g wet wt.)	Mussel	BS	†† 0.166	0.036	6	*t*-tests (log-transformed data)	0.425
		S50	†† 0.130	0.021	6		
		PC	† 0.685 *[3]	0.362	3		
		Day 0	†† 0.080	0.014	3		
	Clam	BS	†† 0.113	0.018	6	*t*-tests (log-transformed data)	0.397
		S50	† 0.314	0.069	6		
		PC	† 0.748	0.308	3		
		Day 0	†† 0.189	0.047	3		
Anthracene (ng/g wet wt.)	Mussel	BS	†† 0.873	0.127	6	Nonparametric Dunnett's test (data converted to rankits)	5.12
		S50	† 2.500	1.500	6		
		PC	† 0.580 **	0.204	3		
		Day 0	† 4.000	3.000	3		
	Clam	BS	†† 0.726	0.174	6	*t*-tests	0.756
		S50	† 0.417	0.133	6		
		PC	†† 0.585	0.449	3		
		Day 0	†† 0.219	0.054	3		
Benz[a]anthracene (ng/g wet wt.)	Mussel	BS	†† 0.651	0.121	6	*t*-tests (log-transformed data)	1.94
		S50	† 2.031 *	0.749	6		
		PC	† 0.494	0.179	3		
		Day 0	†† 0.445	0.073	3		
	Clam	BS	5.165	0.765	6	*t*-tests	2.21
		S50	4.028	0.185	6		
		PC	† 0.804	0.327	3		
		Day 0	2.792	0.773	3		

[1] Minimum significant difference that can be detected by Dunnett's test on untransformed data.
[2] † Mean includes at least one concentration less than DL and set equal to DL/10;
†† All concentrations less than DL and set equal to DL/10. Comparisons in which all treatments for an organism were less than DL are not included in the table.
[3] * Indicates a treatment that is significantly greater than Day 0
** indicates a treatment that is significantly less than Day 0 (two-tailed test, $\alpha/2 = 0.025$).

(Sheet 1 of 22)

Table A11 (Continued)							
Contaminant	**Organ-ism**	**Treat-ment**	**Mean Concen-tration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**Dunnett d_{min}[1]**
Benz[a]an-thracene (continued)	Fish	BS S50 PC Day 0	† 0.252 † 0.355 * †† 0.266 †† 0.106	0.148 0.136 0.045 0.009	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.512
Benzo[a]py-rene (ng/g wet wt.)	Mussel	BS S50 PC Day 0	†† 0.208 † 0.580 2.863 * †† 0.129	0.024 0.218 0.932 0.021	6 6 3 3	*t*-tests (log-transformed data)	1.20
	Clam	BS S50 PC Day 0	4.480 * 5.258 * † 1.172 † 0.347	0.491 0.296 0.220 0.192	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.49
	Fish	BS S50 PC Day 0	† 0.219 †† 0.097 †† 0.238 †† 0.089	0.135 0.013 0.040 0.008	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.346
Benzo[b]fluor-anthene (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 1.951 † 3.186 † 0.530 †† 0.252	0.698 0.874 0.243 0.042	6 6 3 3	*t*-tests	2.85
	Clam	BS S50 PC Day 0	7.398 * 9.985 * † 0.979 2.663	0.767 0.789 0.423 0.297	6 6 3 3	*t*-tests	2.85
Benzo[k]fluor-anthene (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.395 † 0.452 †† 0.214 †† 0.143	0.155 0.196 0.126 0.024	6 6 3 3	Nonparametric Dunnett's test (data converted to rankits)	0.650
	Clam	BS S50 PC Day 0	† 2.522 † 1.810 † 0.732 † 1.181	0.827 1.004 0.296 0.526	6 6 3 3	Dunnett's test (log-transformed data)	3.37
Benzo[g,h,i]-perylene (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.797 † 0.469 † 1.026 * †† 0.067	0.685 0.225 0.467 0.011	6 6 3 3	Nonparametric Dunnett's test (data converted to rankits)	1.90
	Clam	BS S50 PC Day 0	4.538 * 5.910 * † 4.360 †† 0.135	0.441 0.475 2.145 0.031	6 6 3 3	*t*-tests	2.94
Chrysene (ng/g wet wt.)	Mussel	BS S50 PC Day 0	3.185 † 4.505 † 1.915 2.130	0.373 1.261 0.723 0.252	6 6 3 3	Nonparametric Dunnett's test (data converted to rankits)	3.45
	Clam	BS S50 PC Day 0	4.253 5.262 † 2.137 5.527	0.459 0.243 0.535 1.052	6 6 3 3	*t*-tests (log-transformed data)	1.88
Dibenz-[a,h]an-thracene (ng/g wet wt.)	Clam	BS S50 PC Day 0	† 0.644 † 0.594 †† 0.520 †† 0.153	0.361 0.217 0.391 0.035	6 6 3 3	Dunnett's test (log-transformed data)	1.16

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Table A11 (Continued)							
Contaminant	**Organism**	**Treatment**	**Mean Concentration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**Dunnett d_{min}[1]**
Dibenzothiophene (ng/g wet wt.)	Mussel	BS	†† 0.631	0.095	6	Nonparametric Dunnett's test (data converted to rankits)	8.64
		S50	† 4.576	3.402	6		
		PC	† 0.682	0.304	3		
		Day 0	†† 0.429	0.069	3		
	Clam	BS	†† 0.368	0.076	6	*t*-tests	0.595
		S50	† 0.379	0.108	6		
		PC	†† 0.561	0.431	3		
		Day 0	†† 0.210	0.052	3		
Fluoranthene (ng/g wet wt.)	Mussel	BS	6.080	0.715	6	Dunnett's test	2.65
		S50	10.317 *	0.635	6		
		PC	7.013	0.618	3		
		Day 0	4.280	0.714	3		
	Clam	BS	8.915 **	1.041	6	*t*-tests (log-transformed data)	7.35
		S50	13.033	0.551	6		
		PC	† 4.660	2.017	3		
		Day 0	22.567	5.567	3		
Fluorene (ng/g wet wt.)	Mussel	BS	† 2.272 **	0.948	6	Nonparametric *t*-tests (data converted to rankits)	4.19
		S50	† 3.271	1.241	6		
		PC	† 2.767 **	1.100	3		
		Day 0	7.023	0.449	3		
Fluorene (continued)	Clam	BS	† 5.280	1.393	6	*t*-tests	4.69
		S50	† 1.998 **	1.054	6		
		PC	† 3.710	1.007	3		
		Day 0	7.303	0.883	3		
	Fish	BS	† 1.757	0.769	6	*t*-tests	2.26
		S50	† 0.402	0.192	6		
		PC	†† 0.394	0.066	3		
		Day 0	† 1.077	0.901	3		
Indeno[1,2,3-cd]pyrene (ng/g wet wt.)	Mussel	BS	† 0.543	0.228	6	*t*-tests (log-transformed data)	1.91
		S50	†† 0.307	0.050	6		
		PC	3.343	1.550	3		
		Day 0	† 0.616	0.397	3		
	Clam	BS	4.148 *	0.305	6	Nonparametric Dunnett's test (data converted to rankits)	1.42
		S50	4.223 *	0.434	6		
		PC	† 0.911	0.398	3		
		Day 0	†† 0.126	0.029	3		
	Fish	BS	†† 0.083	0.008	6	Nonparametric *t*-tests (data converted to rankits)	2.12
		S50	†† 0.097	0.013	6		
		PC	† 3.096 *	1.870	3		
		Day 0	†† 0.089	0.008	3		
Naphthalene (ng/g wet wt.)	Mussel	BS	48.733	4.594	6	Dunnett's test	15.3
		S50	44.133	4.360	6		
		PC	30.133 **	4.776	3		
		Day 0	54.333	6.640	3		
	Clam	BS	39.337	10.082	6	*t*-tests	24.9
		S50	14.627	4.026	6		
		PC	31.800	10.248	3		
		Day 0	15.200	3.329	3		
	Fish	BS	19.487	3.773	6	*t*-tests	10.9
		S50	† 13.820	3.146	6		
		PC	24.833	0.939	3		
		Day 0	16.833	3.886	3		
							(Sheet 3 of 22)

Table A11 (Continued)							
Contaminant	**Organ-ism**	**Treat-ment**	**Mean Concen-tration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**Dunnett d_{min}[1]**
Phenan-threne (ng/g wet wt.)	Mussel	BS	24.983	1.561	6	Dunnett's test	7.23
		S50	30.600	1.871	6		
		PC	18.933	0.857	3		
		Day 0	27.533	3.187	3		
	Clam	BS	20.200	5.156	6	*t*-tests	14.0
		S50	8.838	1.298	6		
		PC	† 6.523	2.752	3		
		Day 0	8.347	1.520	3		
	Fish	BS	7.342	1.599	6	Dunnett's test	6.23
		S50	† 6.463	1.810	6		
		PC	5.353	0.576	3		
		Day 0	5.560	0.810	3		
Pyrene (ng/g wet wt.)	Mussel	BS	7.185	1.039	6	Dunnett's test (log-transformed data)	4.49
		S50	16.000 *	1.338	6		
		PC	8.420 *	0.911	3		
		Day 0	4.273	0.692	3		
	Clam	BS	8.908	0.916	6	*t*-tests (log-transformed data)	6.03
		S50	13.750	0.671	6		
		PC	† 3.337	1.174	3		
		Day 0	13.563	4.518	3		
Cd (µg/g dry wt.)	Mussel	BS	3.060	0.222	6	*t*-tests (log-transformed data)	0.339
		S50	3.778 *	0.110	6		
		PC	12.363 *	1.906	3		
		Day 0	2.440	0.130	3		
	Clam	BS	0.401	0.032	6	*t*-tests	0.117
		S50	0.403	0.014	6		
		PC	1.743 *	0.065	3		
		Day 0	0.410	0.020	3		
	Fish	BS	0.397	0.018	6	*t*-tests	0.079
		S50	0.390	0.008	6		
		PC	0.614 *	0.043	3		
		Day 0	0.365	0.032	3		
Cr (µg/g dry wt.)	Mussel	BS	0.718 *	0.085	6	Dunnett's test (log-transformed data)	0.301
		S50	0.615 *	0.077	6		
		PC	0.633 *	0.062	3		
		Day 0	0.193	0.019	3		
	Clam	BS	8.150 *	0.666	6	*t*-tests	2.05
		S50	7.833 *	0.300	6		
		PC	2.867	0.291	3		
		Day 0	1.463	0.719	3		
	Fish	BS	0.843	0.167	6	Dunnett's test	0.691
		S50	1.300	0.100	6		
		PC	0.917	0.183	3		
		Day 0	1.210	0.384	3		

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Table A11 (Continued)							
Contaminant	**Organism**	**Treatment**	**Mean Concentration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**Dunnett d_{min}[1]**
Hg (μg/g dry wt.)	Mussel	BS	0.145	0.009	6	*t*-tests	0.030
		S50	0.162	0.007	6		
		PC	0.177 *	0.005	3		
		Day 0	0.143	0.004	3		
	Clam	BS	0.144 *	0.008	6	*t*-tests	0.034
		S50	0.160 *	0.007	6		
		PC	0.171	0.017	3		
		Day 0	0.095	0.003	3		
	Fish	BS	0.260	0.011	6	Nonparametric *t*-tests (data converted to rankits)	0.134
		S50	0.250	0.002	6		
		PC	0.218	0.010	3		
		Day 0	0.304	0.115	3		
TBT (ng/g wet wt.)	Mussel	BS	22.633 *	2.109	6	Dunnett's test (log-transformed data)	7.34
		S50	20.667 *	1.389	6		
		PC	31.333 *	3.122	3		
		Day 0	2.100	0.404	3		
	Clam	BS	20.250 *	1.630	6	Dunnett's test (log-transformed data)	5.19
		S50	16.933 *	0.829	6		
		PC	25.033 *	2.025	3		
		Day 0	1.900	0.231	3		
	Fish	BS	12.140 *	2.394	5	*t*-tests	7.47
		S50	8.933 *	1.116	6		
		PC	15.867	3.755	3		
		Day 0	†† 0.250	0.010	3		
DBT (ng/g wet wt.)	Mussel	BS	10.117 *	0.928	6	Dunnett's test	3.92
		S50	8.467 *	1.163	6		
		PC	15.000 *	0.862	3		
		Day 0	† 0.897	0.364	3		
	Clam	BS	† 1.592	0.443	6	*t*-tests	1.22
		S50	2.500 *	0.124	6		
		PC	3.200 *	0.321	3		
		Day 0	†† 0.253	0.009	3		
	Fish	BS	†† 0.220	0.013	5	Nonparametric *t*-tests (data converted to rankits)	0.465
		S50	†† 0.222	0.005	6		
		PC	† 0.970	0.390	3		
		Day 0	†† 0.240	0.010	3		
MBT (ng/g wet wt.)	Clam	BS	†† 0.878	0.075	6	Nonparametric *t*-tests (data converted to rankits)	5.19
		S50	† 5.152 *	2.042	6		
		PC	†† 0.483	0.038	3		
		Day 0	†† 0.423	0.015	3		
PCB 1 (ng/g wet wt.)	Clam	BS	19.150	14.450	2	*t*-tests	27.9
		S50	18.067	6.172	6		
		Day 0	11.500	2.438	3		
	Fish	BS	22.833	4.355	6	Nonparametric Dunnett's test (data converted to rankits)	1226
		S50	524.083	497.185	6		
		Day 0	13.367	4.591	3		

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Table A11 (Continued)							
Contaminant	**Organism**	**Treatment**	**Mean Concentration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**Dunnett d_{min}[1]**
PCB 8+5 (ng/g wet wt.)	Mussel	BS	5.683	0.666	6	Nonparametric *t*-tests (data converted to rankits)	11.2
		S50	† 5.783	1.506	6		
		PC	† 17.833	9.136	3		
		Day 0	4.867	1.004	3		
	Clam	BS	† 1.683	0.530	6	Nonparametric *t*-tests (data converted to rankits)	9.56
		S50	† 0.192	0.142	6		
		PC	† 16.667	8.331	3		
		Day 0	†† 0.050	0	3		
	Fish	BS	† 0.158	0.108	6	*t*-tests (log-transformed data)	88.8
		S50	† 37.750	34.964	6		
		PC	15.600	3.897	3		
		Day 0	† 1.250	0.895	3		
PCB 17 (ng/g wet wt.)	Mussel	BS	† 0.508	0.201	6	Nonparametric *t*-tests (data converted to rankits)	1.04
		S50	† 0.617	0.356	6		
		PC	†† 0.050	0	3		
		Day 0	†† 0.100	0	3		
	Clam	BS	† 1.550	0.918	6	Nonparametric *t*-tests (data converted to rankits)	7.04
		S50	4.183	0.746	6		
		PC	8.700	5.552	3		
		Day 0	4.267	0.845	3		
	Fish	BS	† 0.608	0.132	6	Dunnett's test (log-transformed data)	1.15
		S50	† 0.533	0.369	6		
		PC	† 0.917	0.442	3		
		Day 0	† 0.550	0.250	3		
PCB 18 (ng/g wet wt.)	Mussel	BS	2.700 *	0.413	6	Nonparametric Dunnett's test (data converted to rankits)	8.09
		S50	† 2.300	0.543	6		
		PC	19.033 *	6.957	3		
		Day 0	† 0.467	0.367	3		
	Clam	BS	† 0.617	0.366	6	*t*-tests (log-transformed data)	2.59
		S50	† 0.733	0.226	6		
		PC	8.900	2.050	3		
		Day 0	† 0.483	0.246	3		
	Mish	BS	† 0.142	0.092	6	Nonparametric *t*-tests (data converted to rankits)	102
		S50	† 40.533	40.254	6		
		PC	2.967	0.835	3		
		Day 0	† 0.633	0.583	3		
PCB 19 (ng/g wet wt.)	Mussel	BS	† 0.142	0.092	6	Nonparametric *t*-tests (data converted to rankits)	3.70
		S50	†† 0.050	0	6		
		PC	8.367 *	3.254	3		
		Day 0	†† 0.050	0	3		
	Clam	BS	† 0.725	0.310	6	Nonparametric *t*-tests (data converted to rankits)	4.65
		S50	† 0.683	0.208	6		
		PC	† 8.050	4.003	3		
		Day 0	0.800	0.208	3		
	Fish	BS	† 0.125	0.075	6	Nonparametric *t*-tests (data converted to rankits)	51.4
		S50	† 20.450	20.270	6		
		PC	† 0.400	0.350	3		
		Day 0	†† 0.050	0	3		

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Table A11 (Continued)							
Contaminant	**Organ-ism**	**Treat-ment**	**Mean Concen-tration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**Dunnett d_{min} [1]**
PCB 22 and PCB 22+51 (ng/g wet wt.)	Mussel	BS	4.483	0.367	6	*t*-tests (log-transformed data)	6.22
		S50	4.617	0.751	6		
		PC	18.267	5.106	3		
		Day 0	6.100	0.721	3		
	Clam	BS	† 1.750	0.509	6	Dunnett's test	3.41
		S50	† 1.867	0.811	6		
		PC	11.267 *	1.408	3		
		Day 0	† 3.100	1.572	3		
	Fish	BS	†† 0.200	0	6	Nonparametric *t*-tests (data converted to rankits)	23.8
		S50	† 9.583	9.383	6		
		PC	5.300 *	1.097	3		
		Day 0	†† 0.200	0	3		
PCB 25 (ng/g wet wt.)	Mussel	BS	8.700 *	2.151	6	*t*-tests (log-transformed data)	8.14
		S50	7.750 *	1.726	6		
		PC	15.333 *	3.670	3		
		Day 0	†† 0.050	0	3		
	Clam	BS	1.950 *	0.492	6	Nonparametric *t*-tests (data converted to rankits)	4.08
		S50	† 0.233	0.119	6		
		PC	† 6.850	3.415	3		
		Day 0	†† 0.050	0	3		
	Fish	BS	† 0.142	0.092	6	Nonparametric *t*-tests (data converted to rankits)	16.0
		S50	† 6.583	6.287	6		
		PC	4.600 *	0.635	3		
		Day 0	†† 0.050	0	3		
PCB 26 (ng/g wet wt.)	Mussel	BS	3.267	0.347	6	Nonparametric Dunnett's test (data converted to rankits)	5.56
		S50	† 2.642	0.609	6		
		PC	9.467 *	4.611	3		
		Day 0	2.433	0.549	3		
PCB 26 (continued)	Clam	BS	† 1.642	0.648	6	Nonparametric *t*-tests (data converted to rankits)	10.3
		S50	4.067	0.950	6		
		PC	† 8.767	8.717	3		
		Day 0	3.567	0.667	3		
	Fish	BS	† 0.433	0.302	6	Nonparametric *t*-tests (data converted to rankits)	44.3
		S50	† 17.617	17.457	6		
		PC	3.367	0.921	3		
		Day 0	† 0.233	0.183	3		
PCB 27 (ng/g wet wt.)	Clam	BS	† 0.050	0	2	Nonparametric *t*-tests (data converted to rankits)	2.01
		S50	† 0.350	0.190	6		
		PC	6.000 *	1.168	3		
		Day 0	†† 0.050	0	3		
	Fish	BS	1.000	0.093	6	Nonparametric Dunnett's test (data converted to rankits)	34.3
		S50	14.350	13.530	6		
		PC	1.400	0.306	3		
		Day 0	0.833	0.120	3		

(Sheet 7 of 22)

Table A11 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
PCB 29 (ng/g wet wt.)	Mussel	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	1.63
		S50	† 0.675	0.625	6		
		PC	† 0.367	0.317	3		
		Day 0	†† 0.050	0	3		
	Clam	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	0.284
		S50	†† 0.050	0	6		
		PC	† 0.300	0.250	3		
		Day 0	†† 0.050	0	3		
	Fish	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	0.359
		S50	†† 0.050	0	6		
		PC	† 0.367	0.317	3		
		Day 0	†† 0.050	0	3		
PCB 31+28 (ng/g wet wt.)	Mussel	BS	12.700	2.706	5	*t*-tests	8.29
		S50	14.050 *	1.430	6		
		PC	10.200	3.305	3		
		Day 0	5.200	0.513	3		
	Clam	BS	6.083 *	1.583	6	Nonparametric Dunnett's test (data converted to rankits)	11.6
		S50	† 0.517	0.298	6		
		PC	† 10.400	9.606	3		
		Day 0	† 0.267	0.217	3		
	Fish	BS	2.683	0.549	6	Nonparametric *t*-tests (data converted to rankits)	14.0
		S50	7.733	5.421	6		
		PC	6.933	1.241	3		
		Day 0	† 1.567	1.517	3		
PCB 32+16 (ng/g wet wt.)	Mussel	BS	4.350	0.616	6	Dunnett's test (log-transformed data)	5.07
		S50	4.400	0.659	6		
		PC	12.167 *	3.941	3		
		Day 0	3.100	0.586	3		
	Clam	BS	† 2.333	0.729	6	Nonparametric Dunnett's test (data converted to rankits)	13.5
		S50	† 4.733	1.566	6		
		PC	18.700	11.000	3		
		Day 0	† 4.683	2.473	3		
	Fish	BS	9.983	0.961	6	Dunnett's test	5.13
		S50	† 7.558	1.618	6		
		PC	† 1.550	0.912	3		
		Day 0	7.533	1.378	3		
PCB 33 and PCB 33+53 (ng/g wet wt.)	Mussel	BS	†† 0.320	0.073	5	Nonparametric *t*-tests (data converted to rankits)	3.18
		S50	†† 0.200	0	5		
		PC	6.833 *	2.215	3		
		Day 0	†† 0.200	0	2		
	Fish	PC	2.467	0.384	3	*t*-test	–
		Day 0	†† 0.050	–	1		
PCB 40 (ng/g wet wt.)	Mussel	BS	1.933	0.407	6	*t*-tests	2.49
		S50	1.567	0.314	6		
		PC	6.267	1.794	3		
		Day 0	† 0.983	0.509	3		
	Clam	BS	† 0.933	0.300	6	Nonparametric *t*-tests (data converted to rankits)	10.8
		S50	†† 0.050	0	6		
		PC	† 11.183	9.461	3		
		Day 0	†† 0.050	0	3		

(Sheet 8 of 22)

Table A11 (Continued)							
Contaminant	**Organism**	**Treatment**	**Mean Concentration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**Dunnett d_{min} [1]**
PCB 40 (continued)	Fish	BS S50 PC Day 0	† 0.267 † 5.367 † 0.533 †† 0.050	0.139 5.207 0.483 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	13.2
PCB 42+37 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.300 † 1.267 22.933 * † 0.367	0.220 0.492 9.275 0.317	6 6 3 3	*t*-tests (log-transformed data)	10.6
	Clam	BS S50 PC Day 0	† 0.317 ** † 0.675 20.000 1.300	0.181 0.290 7.257 0.200	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	8.28
	Fish	BS S50 PC Day 0	†† 0.050 † 1.308 4.900 † 0.300	0 1.258 0.643 0.250	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	3.29
PCB 44 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.600 † 1.433 3.867 1.833	0.308 0.615 0.895 0.636	6 6 3 3	Dunnett's test	2.15
	Clam	BS S50 PC Day 0	5.550 † 0.950 ** † 2.583 2.233	1.771 0.354 1.293 0.145	6 6 3 3	*t*-tests	4.81
	Fish	BS S50 PC Day 0	† 0.217 ** † 4.275 2.267 0.933	0.106 3.948 0.991 0.186	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	10.1
PCB 45 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	4.867 6.083 6.167 6.633	0.533 0.247 2.411 0.371	6 6 3 3	*t*-tests (log-transformed data)	3.14
	Clam	BS S50 PC Day 0	† 2.650 † 0.200 5.233 † 0.200	0.834 0.095 3.290 0.150	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	4.30
	Fish	BS S50 PC Day 0	†† 0.050 † 12.525 1.333 * †† 0.050	0 12.475 0.384 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	31.7
PCB 46 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	†† 0.050 † 0.367 7.967 † 0.233	0 0.225 3.865 0.183	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	4.43
	Clam	BS S50 PC Day 0	† 0.650 † 2.233 4.867 † 1.733	0.334 0.810 1.035 0.769	6 6 3 3	Dunnett's test	2.66
	Fish	BS S50 PC Day 0	† 0.533 † 21.567 3.367 †† 0.150	0.333 21.367 0.903 0.050	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	54.2

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Table A11 (Continued)							
Contaminant	**Organism**	**Treatment**	**Mean Concentration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**Dunnett d_{min}[1]**
PCB 48+47 (ng/g wet wt.)	Mussel	BS	† 6.738	2.411	4	*t*-tests	9.22
		S50	9.433	0.651	6		
		PC	† 7.583	5.761	3		
		Day 0	10.333	1.017	3		
	Clam	BS	† 2.925	1.648	6	*t*-tests	5.89
		S50	† 1.225	0.374	6		
		PC	† 6.717	3.557	3		
		Day 0	†† 0.050	0	3		
	Fish	BS	0.867	0.123	6	Nonparametric *t*-tests (data converted to rankits)	12.4
		S50	† 5.417	4.880	6		
		PC	3.700	0.907	3		
		Day 0	† 0.600	0.550	3		
PCB 49 and PCB 49+43 (ng/g wet wt.)	Mussel	BS	2.667	0.300	6	Nonparametric Dunnett's test (data converted to rankits)	4.28
		S50	2.617	0.209	6		
		PC	7.367 *	3.677	3		
		Day 0	2.000	0.153	3		
	Clam	BS	† 1.467	0.455	6	Nonparametric *t*-tests (data converted to rankits)	7.44
		S50	†† 0.050	0	6		
		PC	9.767 *	6.479	3		
		Day 0	†† 0.050	0	3		
	Fish	BS	† 0.842	0.178	6	*t*-tests (log-transformed data)	6.45
		S50	† 3.150	2.503	6		
		PC	3.333	0.731	3		
		Day 0	† 0.567	0.517	3		
PCB 52 (ng/g wet wt.)	Clam	BS	†† 0.050 **	0	2	Nonparametric *t*-tests (data converted to rankits)	2.15
		S50	† 0.142 **	0.092	6		
		PC	† 2.383	1.315	3		
		Day 0	1.367	0.088	3		
	Fish	BS	1.417	0.196	6	Nonparametric *t*-tests (data converted to rankits)	7.73
		S50	4.200	2.934	6		
		PC	4.800	1.601	3		
		Day 0	† 0.800	0.750	3		
PCB 56+60 (ng/g wet wt.)	Mussel	BS	0.750	0.092	6	*t*-tests (log-transformed data)	11.5
		S50	† 0.700	0.312	6		
		PC	24.067	10.133	3		
		Day 0	† 0.783	0.419	3		
	Clam	BS	† 0.317 **	0.169	6	*t*-tests (log-transformed data)	6.16
		S50	† 0.692	0.168	6		
		PC	† 10.533	5.397	3		
		Day 0	1.500	0.115	3		
	Fish	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	2.87
		S50	† 0.958	0.908	6		
		PC	† 1.700 *	1.500	3		
		Day 0	†† 0.050	0	3		

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Table A11 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
PCB 63 (ng/g wet wt.)	Mussel	BS	8.433 *	2.257	6	*t*-tests	9.98
		S50	6.367 *	1.424	6		
		PC	19.467	6.458	3		
		Day 0	†† 0.050	0	3		
	Clam	BS	3.367	0.884	6	*t*-tests (log-transformed data)	7.85
		S50	0.967	0.071	6		
		PC	† 11.717	6.222	3		
		Day 0	† 2.517	2.294	3		
	Fish	BS	5.100 *	0.656	6	*t*-tests	3.44
		S50	† 3.558	1.010	6		
		PC	8.933	1.384	3		
		Day 0	†† 0.050	0	3		
PCB 70+76 (ng/g wet wt.)	Mussel	BS	†† 0.200	0	6	Nonparametric *t*-tests (data converted to rankits)	5.86
		S50	†† 0.200	0	6		
		PC	10.233 *	5.162	3		
		Day 0	†† 0.200	0	3		
	Clam	BS	† 0.333	0.088	6	*t*-tests (log-transformed data)	1.68
		S50	† 0.425	0.181	6		
		PC	12.967	1.387	3		
		Day 0	† 0.300	0.250	3		
	Fish	BS	† 0.625	0.314	6	Nonparametric *t*-tests (data converted to rankits)	3.90
		S50	† 1.767	1.463	6		
		PC	† 1.700	0.764	3		
		Day 0	†† 0.050	0	3		
PCB 74 (ng/g wet wt.)	Mussel	BS	† 0.558	0.255	6	*t*-tests (log-transformed data)	6.24
		S50	† 0.742 *	0.200	6		
		PC	† 9.250	5.446	3		
		Day 0	†† 0.050	0	3		
	Clam	BS	†† 0.050 **	0	6	Nonparametric *t*-tests (data converted to rankits)	5.93
		S50	† 0.275 **	0.225	6		
		PC	10.033	5.197	3		
		Day 0	1.467	0.167	3		
	Fish	BS	† 0.233	0.119	6	Nonparametric *t*-tests (data converted to rankits)	3.12
		S50	† 1.275	1.225	6		
		PC	†† 0.050	0	3		
		Day 0	†† 0.050	0	3		
PCB 82 (ng/g wet wt.)	Mussel	BS	† 0.217	0.106	6	Nonparametric *t*-tests (data converted to rankits)	3.50
		S50	† 0.400	0.235	6		
		PC	7.067 *	3.022	3		
		Day 0	† 0.233	0.183	3		
	Clam	BS	† 6.025	1.705	6	Nonparametric Dunnett's test (data converted to rankits)	20.5
		S50	† 1.950	0.865	6		
		PC	36.800 *	17.501	3		
		Day 0	3.667	1.135	3		
	Fish	BS	† 0.375	0.148	6	Nonparametric *t*-tests (data converted to rankits)	0.983
		S50	† 0.525 *	0.103	6		
		PC	† 1.583	0.767	3		
		Day 0	†† 0.050	0	3		
PCB 83 (ng/g wet wt.)	Mussel	BS	† 0.408	0.161	6	*t*-tests	0.620
		S50	† 0.758 *	0.193	6		
		Day 0	†† 0.050	0	3		

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Table A11 (Continued)							
Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
PCB 84 and PCB 92+84 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 1.475 † 1.308 22.500 * † 0.500	0.418 0.354 10.293 0.450	6 6 3 3	Dunnett's test (log-transformed data)	11.8
	Clam	BS S50 PC Day 0	† 0.775 ** † 1.217 ** † 4.150 3.300	0.371 0.382 2.146 0.451	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	2.83
	Fish	BS S50 PC Day 0	† 0.175 ** † 1.250 6.033 1.067	0.125 1.057 1.934 0.318	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	3.50
PCB 85 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	2.483 2.367 14.600 * 2.467	0.277 0.291 4.751 0.328	6 6 3 3	Dunnett's test (log-transformed data)	5.50
	Clam	BS S50 PC Day 0	0.817 † 0.608 † 4.917 † 0.300	0.095 0.121 2.593 0.250	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	2.98
	Fish	BS S50 PC Day 0	1.667 † 1.375 13.300 1.833	0.152 0.318 0.917 0.067	6 6 3 3	Nonparametric Dunnett's test (data converted to rankits)	1.37
PCB 87 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.375 † 0.325 8.400 † 0.300	0.152 0.123 4.551 0.250	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	5.20
	Clam	BS S50 PC Day 0	†† 0.050 † 0.208 10.000 † 0.500	0 0.158 5.208 0.450	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	5.95
	Fish	BS S50 PC Day 0	† 0.342 †† 0.050 2.133 †† 0.050	0.136 0 0.817 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.990
PCB 91 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.608 † 0.567 † 2.017 † 0.400	0.281 0.223 1.043 0.350	6 6 3 3	*t*-tests	1.55
	Clam	BS S50 PC Day 0	† 0.125 †† 0.050 7.833 † 0.167	0.075 0 2.598 0.117	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	2.96
	Fish	BS S50 PC Day 0	† 0.142 † 0.675 1.867 * †† 0.050	0.092 0.625 0.657 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.77

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Table A11 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
PCB 95+66 (ng/g wet wt.)	Mussel	BS	† 1.850	1.465	5	Dunnett's test (log-transformed data)	17.2
		S50	† 1.300	0.800	6		
		PC	22.933	13.530	3		
		Day 0	† 3.900	1.704	3		
	Clam	BS	5.167	1.035	6	*t*-tests (log-transformed data)	9.87
		S50	3.533	0.439	6		
		PC	22.567	8.183	3		
		Day 0	† 3.067	1.525	3		
	Fish	BS	4.417	0.264	6	Nonparametric *t*-tests (data converted to rankits)	2.74
		S50	† 3.433	0.717	6		
		PC	6.833	1.648	3		
		Day 0	3.267	0.448	3		
PCB 97 (ng/g wet wt.)	Mussel	BS	† 1.450	0.536	6	Nonparametric *t*-tests (data converted to rankits)	5.57
		S50	† 1.567	0.497	6		
		PC	11.633 *	4.610	3		
		Day 0	† 0.467	0.367	3		
	Clam	BS	†† 0.100	0	6	Nonparametric *t*-tests (data converted to rankits)	0.785
		S50	†† 0.100	0	6		
		PC	9.467	0.561	3		
		Day 0	† 0.767	0.406	3		
	Fish	BS	†† 0.100	0	6	Nonparametric *t*-tests (data converted to rankits)	1.95
		S50	†† 0.100 4.333	0	6		
		PC	*	1.715	3		
		Day 0	†† 0.100	0	3		
PCB 99 (ng/g wet wt.)	Mussel	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	9.43
		S50	† 0.275	0.225	6		
		PC	† 11.483	8.291	3		
		Day 0	†† 0.050	0	3		
	Fish	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	0.927
		S50	† 0.225	0.175	6		
		PC	† 0.767	0.717	3		
		Day 0	†† 0.050	0	3		
PCB 100 (ng/g wet wt.)	Mussel	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	5.41
		S50	† 0.275	0.225	6		
		PC	10.733	4.637	3		
		Day 0	† 1.033	0.983	3		
	Clam	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	18.1
		S50	†† 0.050	0	6		
		PC	22.833	15.987	3		
		Day 0	† 0.167	0.117	3		
	Fish	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	6.67
		S50	† 2.642	2.592	6		
		PC	2.933 *	0.977	3		
		Day 0	†† 0.050	0	3		

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Table A11 (Continued)							
Contaminant	**Organ-ism**	**Treat-ment**	**Mean Concen-tration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**Dunnett d_{min}[1]**
PCB 101 and PCB 101+89 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.683 † 0.567 6.167 * 0.700	0.215 0.190 2.562 0.115	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	3.00
	Clam	BS S50 PC Day 0	†† 0.050 †† 0.050 † 6.633 † 0.200	0 0 6.583 0.150	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	7.47
	Fish	BS S50 PC Day 0	†† 0.050 † 0.392 2.400 †† 0.050	0 0.342 0.850 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.30
PCB 110 and PCB 110+77 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.917 † 0.750 5.900 * 0.833	0.289 0.283 3.066 0.088	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	3.63
	Clam	BS S50 PC Day 0	† 0.450 †† 0.050 † 2.767 †† 0.050	0.253 0 2.717 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	3.15
	Fish	BS S50 PC Day 0	†† 0.050 †† 0.050 † 0.867 †† 0.050	0 0 0.817 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.927
PCB 118 and PCB 118+149 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	1.000 † 0.908 † 0.233 1.367	0.157 0.211 0.183 0.033	6 6 3 3	*t*-tests	0.700
	Clam	BS S50 PC Day 0	† 0.142 †† 0.050 † 3.767 †† 0.050	0.092 0 3.717 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	4.22
	Fish	BS S50 PC Day 0	†† 0.050 †† 0.050 † 0.200 †† 0.050	0 0 0.150 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.170
PCB 128 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 1.350 † 1.033 12.600 1.633	0.425 0.498 9.188 0.233	6 6 3 3	Nonparametric Dunnett's test (data converted to rankits)	10.6
	Clam	BS S50 PC Day 0	†† 0.050 †† 0.050 † 6.450 †† 0.050	0 0 3.476 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	3.94
	Fish	BS S50 PC Day 0	†† 0.050 †† 0.050 † 2.883 †† 0.050	0 0 1.418 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.61
PCB 131 (ng/g wet wt.)	Mussel	BS S50 Day 0	† 0.142 † 0.233 †† 0.050	0.092 0.119 0	6 6 3	Nonparametric *t*-tests (data converted to rankits)	0.370
							(Sheet 14 of 22)

Table A11 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
PCB 134+114 (ng/g wet wt.)	Mussel	BS S50 Day 0	† 0.208 † 0.550 †† 0.050	0.158 0.182 0	6 6 3	*t*-tests (log-transformed data)	0.594
	Clam	BS S50 Day 0	0.833 * 0.900 * †† 0.050	0.080 0.063 0	6 6 3	*t*-tests	0.252
	Fish	BS S50 Day 0	† 0.558 † 0.208 † 0.233	0.107 0.158 0.183	6 6 3	Dunnett's test (log-transformed data)	0.513
PCB 135+144 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.867 † 0.717 1.933 †† 0.200	0.667 0.356 0.797 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	2.12
	Clam	BS S50 PC Day 0	† 0.467 †† 0.100 1.867 * †† 0.100	0.307 0 0.418 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.913
	Fish	BS S50 PC Day 0	†† 0.100 †† 0.100 † 0.650 †† 0.083	0 0 0.301 0.017	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.343
PCB 136 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.208 †† 0.050 10.300 * †† 0.050	0.158 0 2.593 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	2.97
	Clam	BS S50 PC Day 0	†† 0.050 †† 0.050 30.367 * †† 0.050	0 0 9.873 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	11.2
	Fish	BS S50 PC Day 0	†† 0.050 †† 0.050 2.633 * †† 0.050	0 0 1.041 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.18
PCB 137+176 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.325 † 0.408 † 1.833 † 0.450	0.126 0.191 1.783 0.202	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	2.12
	Clam	BS S50 PC Day 0	†† 0.050 †† 0.050 † 3.283 †† 0.050	0 0 1.653 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.88
	Fish	BS S50 PC Day 0	†† 0.050 †† 0.050 † 1.183 †† 0.050	0 0 0.873 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.991

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Table A11 (Continued)							
Contaminant	Organ-ism	Treat-ment	Mean Concen-tration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
PCB 141 (ng/g wet wt.)	Mussel	BS	† 1.183 **	0.595	6	*t*-tests	3.02
		S50	† 2.383	0.733	6		
		PC	† 3.133	1.598	3		
		Day 0	3.467	0.233	3		
	Clam	BS	† 2.333	0.749	6	*t*-tests	3.15
		S50	† 0.592	0.289	6		
		PC	† 4.067	1.947	3		
		Day 0	† 1.183	0.830	3		
	Fish	BS	1.250 *	0.128	6	*t*-tests	0.572
		S50	† 0.442	0.185	6		
		PC	†† 0.200	0	3		
		Day 0	†† 0.050	0	3		
PCB 146 (ng/g wet wt.)	Mussel	BS	† 1.583 **	0.818	6	*t*-tests	3.61
		S50	† 4.083	0.777	6		
		PC	† 3.250	1.924	3		
		Day 0	4.600	0.265	3		
	Clam	BS	† 3.050	0.970	6	Nonparametric *t*-tests (data converted to rankits)	2.59
		S50	†† 0.050	0	6		
		PC	† 0.767	0.717	3		
		Day 0	†† 0.050	0	3		
	Fish	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	0.208
		S50	†† 0.050	0	6		
		PC	† 0.233	0.183	3		
		Day 0	†† 0.050	0	3		
PCB 149 (ng/g wet wt.)	Mussel	BS	† 0.767	0.268	6	Dunnett's test	0.912
		S50	† 0.667	0.250	6		
		Day 0	0.767	0.120	3		
	Fish	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	0.185
		S50	† 0.125	0.075	6		
		Day 0	†† 0.050	0	3		
PCB 151 (ng/g wet wt.)	Mussel	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	2.92
		S50	† 0.267	0.139	6		
		PC	5.300 *	2.554	3		
		Day 0	†† 0.050	0	3		
	Clam	BS	† 0.142	0.092	6	Nonparametric *t*-tests (data converted to rankits)	0.233
		S50	†† 0.050	0	6		
		PC	†† 0.050	0	3		
		Day 0	†† 0.050	0	3		
	Fish	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	1.07
		S50	†† 0.050	0	6		
		PC	† 1.750	0.941	3		
		Day 0	†† 0.050	0	3		

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Table A11 (Continued)							
Contaminant	**Organ-ism**	**Treat-ment**	**Mean Concen-tration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**Dunnett d_{min}[1]**
PCB 153+132+105 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 2.800 4.367 † 6.733 4.567	0.847 0.327 3.725 0.233	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	4.82
	Clam	BS S50 PC Day 0	† 2.583 †† 0.100 † 3.767 †† 0.100	0.799 0 3.567 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	4.53
	Fish	BS S50 PC Day 0	†† 0.100 †† 0.100 † 1.767 * †† 0.100	0 0 0.797 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.904
PCB 157+200 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.517 † 0.433 11.100 0.867	0.170 0.133 6.144 0.088	6 6 3 3	Nonparametric Dunnett's test (data converted to rankits)	6.99
	Clam	BS S50 PC Day 0	†† 0.050 †† 0.050 † 3.683 †† 0.050	0 0 1.890 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	2.14
	Fish	BS S50 PC Day 0	† 0.125 †† 0.050 2.767 † 0.383	0.075 0 1.084 0.169	6 6 3 3	*t*-tests (log-transformed data)	1.26
PCB 158 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.475 † 0.500 7.067 * 0.667	0.205 0.208 2.706 0.088	6 6 3 3	*t*-tests (log-transformed data)	3.16
	Clam	BS S50 PC Day 0	† 0.192 †† 0.050 † 1.983 †† 0.050	0.142 0 1.317 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.54
	Fish	BS S50 PC Day 0	† 0.125 †† 0.050 † 1.350 †† 0.050	0.075 0 0.832 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.963
PCB 163+138 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	1.533 1.450 †† 0.050 ** 1.400	0.178 0.257 0 0.115	6 6 3 3	*t*-tests	0.803
	Clam	BS S50 PC Day 0	† 1.225 * † 0.417 † 7.367 †† 0.050	0.352 0.119 7.317 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	8.36
	Fish	BS S50 PC Day 0	0.700 * † 0.725 † 0.050 † 0.200	0.037 0.205 0 0.150	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.555
PCB 170+190 (ng/g wet wt.)	Clam	BS S50 PC Day 0	1.350 ** 2.800 8.900 3.167	0.281 0.524 3.570 0.186	6 6 3 3	*t*-tests (log-transformed data)	4.33

(Sheet 17 of 22)

Table A11 (Continued)							
Contaminant	**Organ-ism**	**Treat-ment**	**Mean Concen-tration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**Dunnett d_{min}[1]**
PCB 172+197 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.158 † 0.125 13.600 * †† 0.050	0.108 0.075 5.292 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	6.01
	Clam	BS S50 PC Day 0	†† 0.050 †† 0.050 † 4.383 †† 0.050	0 0 2.323 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	2.64
	Fish	BS S50 PC Day 0	†† 0.050 †† 0.050 4.033 * †† 0.050	0 0 1.637 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.86
PCB 173 (ng/g wet wt.)	Mussel	BS S50 Day 0	3.617 4.017 3.033	0.279 0.830 0.033	6 6 3	*t*-tests	2.16
PCB 174 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.292 † 0.433 † 0.867 †† 0.050	0.242 0.319 0.817 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.37
	Clam	BS S50 PC Day 0	†† 0.050 †† 0.050 † 0.300 † 0.133	0 0 0.250 0.083	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.299
	Fish	BS S50 PC Day 0	†† 0.050 †† 0.050 † 2.017 †† 0.050	0 0 0.983 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.12
PCB 175 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.425 † 0.342 †† 0.050 0.767	0.174 0.146 0 0.120	6 6 3 3	*t*-tests	0.591
	Clam	BS S50 PC Day 0	†† 0.050 †† 0.050 † 23.467 †† 0.050	0 0 23.417 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	26.6
	Fish	BS S50 PC Day 0	†† 0.050 †† 0.050 † 1.550 †† 0.050	0 0 0.759 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.861
PCB 177 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.358 † 0.475 9.367 * † 0.383	0.148 0.192 3.541 0.169	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	4.07
	Clam	BS S50 PC Day 0	†† 0.050 †† 0.050 † 6.583 †† 0.050	0 0 3.515 C	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	3.99
	Fish	BS S50 PC Day 0	†† 0.050 †† 0.050 † 1.217 †† 0.050	0 0 0.586 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.665

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Table A11 (Continued)							
Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
PCB 178 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	†† 0.067 † 0.208 20.200 * †† 0.050	0.011 0.158 6.830 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	7.76
	Clam	BS S50 PC Day 0	†† 0.050 †† 0.050 † 5.250 †† 0.050	0 0 2.670 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	3.03
	Fish	BS S50 PC Day 0	† 0.142 † 0.708 4.500 †† 0.050	0.092 0.658 1.952 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	2.78
PCB 180 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	†† 0.200 †† 0.200 † 5.267 †† 0.200	0 0 3.170 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	3.60
	Fish	BS S50 PC Day 0	† 0.125 †† 0.050 † 3.067 †† 0.050	0.075 0 1.438 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.64
PCB 183 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.650 ** † 0.558 ** † 1.933 1.400	0.192 0.247 1.883 0.115	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	2.28
	Clam	BS S50 PC Day 0	†† 0.050 †† 0.050 † 0.600 †† 0.050	0 0 0.550 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.624
	Fish	BS S50 PC Day 0	†† 0.050 †† 0.050 † 2.350 †† 0.050	0 0 1.151 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.31
PCB 185	Fish	BS S50 PC Day 0	†† 0.050 †† 0.050 † 0.983 †† 0.050	0 0 0.468 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.531
PCB 187+182 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.733 † 0.492 † 5.767 1.000	0.227 0.259 3.673 0.058	6 6 3 3	*t*-tests (log-transformed data)	4.26
	Clam	BS S50 PC Day 0	†† 0.050 † 0.250 † 4.600 †† 0.050	0 0.127 2.364 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	2.70
	Fish	BS S50 PC Day 0	†† 0.050 †† 0.050 † 2.267 * †† 0.050	0 0 1.035 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.17
PCB 189 (ng/g wet wt.)	Mussel	BS S50 Day 0	† 0.242 † 0.333 †† 0.050	0.192 0.221 0	6 6 3	Nonparametric *t*-tests (data converted to rankits)	0.773
							(Sheet 19 of 22)

Table A11 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min} [1]
PCB 191 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.242 † 0.317 † 0.400 †† 0.050	0.192 0.220 0.350 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.841
	Fish	BS S50 PC Day 0	†† 0.050 †† 0.050 † 0.650 †† 0.050	0 0 0.301 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.342
PCB 193 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.208 † 0.242 †† 0.050 †† 0.050	0.158 0.192 0 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.631
	Clam	BS S50 PC Day 0	†† 0.050 †† 0.050 † 3.317 † 0.167	0 0 1.984 0.117	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	2.26
	Fish	BS S50 PC Day 0	†† 0.050 †† 0.050 † 0.750 †† 0.050	0 0 0.350 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.397
PCB 194 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	†† 0.050 †† 0.050 † 4.083 †† 0.050	0 0 2.896 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	3.29
	Fish	BS S50 PC Day 0	†† 0.050 †† 0.050 † 1.650 †† 0.050	0 0 0.813 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.922
PCB 198 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.142 †† 0.050 † 4.417 † 0.350	0.092 0 3.901 0.150	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	4.44
	Clam	BS S50 PC Day 0	†† 0.050 †† 0.050 † 9.617 †† 0.050	0 0 6.936 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	7.87
	Fish	BS S50 PC Day 0	†† 0.050 † 0.725 † 0.200 †† 0.050	0 0.675 0.150 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.72
PCB 199 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	†† 0.050 † 0.208 4.300 * †† 0.050	0 0.158 2.128 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	2.45
	Clam	BS S50 PC Day 0	†† 0.050 †† 0.050 † 6.050 †† 0.050	0 0 3.508 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	3.98

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Table A11 (Continued)							
Contaminant	**Organism**	**Treatment**	**Mean Concentration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**Dunnett d_{min}[1]**
PCB 201 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.142 † 0.142 † 4.200 †† 0.050	0.092 0.092 2.802 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	3.20
	Clam	BS S50 PC Day 0	†† 0.050 †† 0.050 6.200 * †† 0.050	0 0 1.986 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	2.25
	Fish	BS S50 PC Day 0	†† 0.050 †† 0.050 † 2.500 * †† 0.050	0 0 1.159 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.32
PCB 202+171 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.408 † 0.333 † 4.800 1.233	0.188 0.181 4.750 0.296	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	5.44
	Clam	BS S50 PC Day 0	† 1.000 † 0.208 † 2.383 †† 0.050	0.321 0.158 1.403 0	6 6 3 3	*t*-tests (log-transformed data)	1.83
	Fish	BS S50 PC Day 0	† 0.142 †† 0.050 †† 0.050 †† 0.050	0.092 0 0 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.233
PCB 203+196 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.158 † 0.208 † 6.333 †† 0.050	0.108 0.158 3.839 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	4.38
	Clam	BS S50 PC Day 0	†† 0.050 †† 0.050 16.267 * †† 0.050	0 0 3.919 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	4.45
	Fish	BS S50 PC Day 0	†† 0.050 †† 0.050 † 1.400 * †† 0.050	0 0 1.200 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.36
PCB 205 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	†† 0.050 †† 0.050 1.833 * †† 0.050	0 0 0.669 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.759
	Clam	BS S50 PC Day 0	†† 0.050 †† 0.050 † 7.817 †† 0.050	0 0 7.006 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	7.95
	Fish	BS S50 PC Day 0	†† 0.050 †† 0.050 † 0.917 †† 0.050	0 0 0.478 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.543

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Table A11 (Concluded)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
PCB 207 (ng/g wet wt.)	Mussel	BS	† 0.225	0.175	6	Nonparametric *t*-tests (data converted to rankits)	3.31
		S50	† 0.450	0.353	6		
		PC	4.933	2.779	3		
		Day 0	†† 0.050	0	3		
	Clam	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	0.813
		S50	†† 0.050	0	6		
		PC	† 0.767	0.717	3		
		Day 0	†† 0.050	0	3		
	Fish	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	1.53
		S50	†† 0.050	0	6		
		PC	† 1.400	1.350	3		
		Day 0	†† 0.050	0	3		
PCB 208+195 (ng/g wet wt.)	Mussel	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	8.12
		S50	†† 0.050	0	6		
		PC	† 7.200	7.150	3		
		Day 0	† 0.233	0.183	3		
	Clam	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	10.3
		S50	†† 0.050	0	6		
		PC	† 14.817	9.062	3		
		Day 0	†† 0.050	0	3		
	Fish	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	0.397
		S50	†† 0.050	0	6		
		PC	† 0.400	0.350	3		
		Day 0	†† 0.050	0	3		
Lipid (percent wet wt.)	Mussel	BS	2.295	0.111	6	*t*-tests	0.666
		S50	2.109	0.101	6		
		PC	2.236	0.477	3		
		Day 0	2.361	0.065	3		
	Clam	BS	1.467	0.212	6	Dunnett's test (log-transformed data)	0.707
		S50	1.216	0.111	6		
		PC	3.512 *	0.229	3		
		Day 0	1.638	0.222	3		
	Fish	BS	1.064	0.069	6	Nonparametric Dunnett's test (data converted to rankits)	0.965
		S50	1.119	0.063	6		
		PC	2.537	0.812	3		
		Day 0	1.377	0.143	3		

Table A12.
Descriptive Statistics and Statistical Comparisons of Contaminant Bioaccumulation and Lipid in Fish (*Citharichthys stigmaeus*), Clams (*Macoma nasuta*), and Mussels (*Mytilus edulis*) Exposed to Berkeley Flats Reference Sediment for 28 Days

Contaminant	Organism	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
Acenaphthene (ng/g wet wt.)	Mussel	† 1.188[2] A[3]	0.339	15	Nonparametric LSD test (data converted to rankits)	0.942
	Clam	† 1.082 A	0.317	15		
	Fish	† 0.840 A	0.309	15		
Acenaphthylene (ng/g wet wt.)	Clam	† 0.320 A	0.085	15	LSD test (log-transformed data)	0.163
	Mussel	† 0.255 A	0.086	15		
	Fish	†† 0.170 A	0.023	15		
Anthracene (ng/g wet wt.)	Mussel	† 1.465 A	0.614	15	*t*-tests (log-transformed data)	1.04
	Clam	† 0.574 B	0.118	15		
	Fish	†† 0.182 C	0.023	15		
Benz[a]anthracene (ng/g wet wt.)	Clam	† 3.838 A	0.524	15	LSD test (log-transformed data)	0.949
	Mussel	† 1.172 B	0.344	15		
	Fish	† 0.296 C	0.077	15		
Benzo[a]pyrene (ng/g wet wt.)	Clam	† 4.130 A	0.462	15	*t*-tests (log-transformed data)	0.941
	Mussel	† 0.888 B	0.322	15		
	Fish	† 0.174 C	0.054	15		
Benzo[b]fluoranthene (ng/g wet wt.)	Clam	† 7.149 A	0.976	15	*t*-tests (log-transformed data)	1.50
	Mussel	† 2.161 B	0.500	15		
	Fish	†† 0.130 C	0.020	15		
Benzo[k]fluoranthene (ng/g wet wt.)	Clam	† 1.879 A	0.524	15	*t*-tests (log-transformed data)	0.887
	Mussel	† 0.382 A	0.099	15		
	Fish	†† 0.129 B	0.020	15		
Benzo[g,h,i]-perylene (ng/g wet wt.)	Clam	† 5.051 A	0.476	15	Nonparametric LSD test (data converted to rankits)	1.02
	Mussel	† 0.712 B	0.289	15		
	Fish	† 0.406 B	0.247	15		
Chrysene (ng/g wet wt.)	Clam	† 4.233 A	0.374	15	Nonparametric LSD test (data converted to rankits)	1.03
	Mussel	† 3.459 A	0.574	15		
	Fish	†† 0.128 B	0.018	15		
Dibenz[a,h]anthracene (ng/g wet wt.)	Clam	† 0.599 A	0.173	15	*t*-tests (log-transformed data)	0.310
	Mussel	†† 0.439 AB	0.059	15		
	Fish	†† 0.144 B	0.022	15		
Dibenzothiophene (ng/g wet wt.)	Mussel	† 2.219 A	1.386	15	Nonparametric LSD test (data converted to rankits)	2.30
	Clam	† 0.411 B	0.090	15		
	Fish	†† 0.174 C	0.022	15		
Fluoranthene (ng/g wet wt.)	Clam	† 9.711 A	1.006	15	*t*-tests	1.59
	Mussel	7.961 A	0.644	15		
	Fish	†† 0.145 B	0.020	15		

[1] Minimum significant difference that can be detected by LSD test on untransformed data.
[2] † Mean includes at least one concentration less than DL and set equal to DL/10;
†† All concentrations less than DL and set equal to DL/10.
[3] For a given contaminant, means followed by the same letter are not significantly different from each other (two-tailed test, $\alpha/2 = 0.025$).

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Table A12 (Continued)

Contaminant	Organism	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
Fluorene (ng/g wet wt.)	Clam Mussel Fish	† 3.653 A † 2.771 A † 0.943 B	0.787 0.630 0.349	15 15 15	LSD test (log-transformed data)	1.75
Indeno[1,2,3-cd]pyrene (ng/g wet wt.)	Clam Mussel Fish	† 3.531 A † 1.009 B † 0.691 C	0.409 0.418 0.451	15 15 15	Nonparametric *t*-tests (data converted to rankits)	1.22
Naphthalene (ng/g wet wt.)	Mussel Clam Fish	43.17 A 27.95 B † 18.29 B	3.12 5.37 2.17	15 15 15	*t*-tests	10.3
Phenanthrene (ng/g wet wt.)	Mussel Clam Fish	26.02 A † 12.92 B † 6.592 B	1.489 2.613 0.939	15 15 15	*t*-tests	4.91
Pyrene (ng/g wet wt.)	Mussel Clam Fish	10.958 A † 9.731 A †† 0.123 B	1.288 1.135 0.017	15 15 15	LSD test (log-transformed data)	2.13
Cd (µg/g dry wt.)	Mussel Clam Fish	5.208 A 0.670 B 0.438 B	1.017 0.144 0.026	15 15 15	Nonparametric LSD test (data converted to rankits)	1.35
Cr (µg/g dry wt.)	Clam Fish Mussel	6.967 A 1.041 B 0.660 C	0.617 0.098 0.046	15 15 15	LSD test (log-transformed data)	0.902
Hg (µg/g dry wt.)	Fish Mussel Clam	0.248 A 0.158 B 0.156 B	0.0061 0.0055 0.0057	15 15 15	LSD test	0.0167
TBT (ng/g wet wt.)	Mussel Clam Fish	23.59 A 19.88 B 11.56 C	1.522 1.107 1.357	15 15 14	LSD test	3.02
DBT (ng/g wet wt.)	Mussel Clam Fish	10.433 A † 2.277 B † 0.381 C	0.865 0.245 0.111	15 15 14	Nonparametric LSD test (data converted to rankits)	1.34
MBT (ng/g wet wt.)	Clam Fish Mussel	† 2.509 A †† 0.459 B †† 0.294 C	0.965 0.011 0.018	15 15 14	Nonparametric LSD test (data converted to rankits)	1.57
Heptachlor (ng/g wet wt.)	Fish Mussel Clam	4.067 A † 1.467 A †† 0.500 A	0.619 0.967 0	3 3 3	*t*-tests	2.29
Heptachlor Epoxide (ng/g wet wt.)	Mussel Clam Fish	† 1.4 A †† 0.5 A †† 0.5 A	0.9 0 0	3 3 3	Nonparametric *t*-tests (data converted to rankits)	1.80
α-Chlordane (ng/g wet wt.)	Mussel Fish Clam	4.950 A † 1.383 A †† 0.500 A	0.862 0.883 0	3 3 3	*t*-tests	2.47

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Table A12 (Continued)						
Contaminant	**Organism**	**Mean Concentration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**LSD d_{min}[1]**
γ-Chlordane (ng/g wet wt.)	Mussel Fish Clam	13.217 A †† 2.633 B † 0.992 B	3.085 1.162 0.492	3 3 3	LSD test	6.66
DDE (ng/g wet wt.)	Fish Mussel Clam	3.683 A † 1.733 A †† 0.500 A	0.636 1.233 0	3 3 3	*t*-tests	2.77
DDD (ng/g wet wt.)	Mussel Fish Clam	232.350 A 61.750 B 30.867 B	24.369 33.854 4.992	3 3 3	*t*-tests	83.9
DDT (ng/g wet wt.)	Mussel Fish Clam	454.267 A 416.733 A 30.975 B	91.052 12.469 4.628	3 3 3	*t*-tests (log-transformed data)	184
PCB 1 (ng/g wet wt.)	Fish Clam	273.458 A 18.338 A	248.786 5.282	12 8	Nonparametric *t*-test (data converted to rankits)	647
PCB 8+5 (ng/g wet wt.)	Fish Mussel Clam	† 18.283 AB † 8.153 A † 4.083 B	13.978 2.109 2.210	15 15 15	Nonparametric *t*-tests (data converted to rankits)	23.7
PCB 17 (ng/g wet wt.)	Clam Fish Mussel	† 4.033 A † 0.640 B † 0.460 B	1.252 0.170 0.165	15 15 15	Nonparametric *t*-tests (data converted to rankits)	2.05
PCB 18 (ng/g wet wt.)	Fish Mussel Clam	† 16.863 B † 5.807 A † 2.320 B	16.070 2.139 0.959	15 15 15	Nonparametric *t*-tests (data converted to rankits)	27.0
PCB 19 (ng/g wet wt.)	Fish Clam Mussel	† 8.310 A † 2.173 A † 1.750 A	8.107 1.046 1.042	15 15 15	Nonparametric *t*-tests (data converted to rankits)	13.7
PCB 22 and PCB 22+51 (ng/g wet wt.)	Mussel Fish Clam	† 7.293 A † 4.973 B † 3.700 B	1.731 3.725 1.100	15 15 15	*t*-tests (log-transformed data)	6.66
PCB 25 (ng/g wet wt.)	Mussel Fish Clam	9.647 A † 3.610 B † 2.243 B	1.436 2.504 0.889	15 15 15	*t*-tests (log-transformed data)	4.87
PCB 26 (ng/g wet wt.)	Fish Mussel Clam	† 7.893 B † 4.257 A † 4.037 AB	6.939 1.081 1.686	15 15 15	*t*-tests (log-transformed data)	12.0
PCB 27 (ng/g wet wt.)	Mussel Fish Clam	7.400 A 6.420 AB † 1.837 B	2.524 5.399 0.858	3 15 11	Nonparametric *t*-tests (data converted to rankits)	14.8
PCB 29 (ng/g wet wt.)	Mussel Fish Clam	† 0.363 A † 0.113 A † 0.100 A	0.253 0.063 0.050	15 15 15	Nonparametric *t*-tests (data converted to rankits)	0.440
						(Sheet 3 of 8)

Table A12 (Continued)

Contaminant	Organism	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 31+28 (ng/g wet wt.)	Mussel Fish Clam	12.743 A 5.553 B † 4.720 B	1.290 2.164 2.007	14 15 15	Nonparametric *t*-tests (data converted to rankits)	5.49
PCB 32+16 (ng/g wet wt.)	Fish Clam Mussel	† 7.327 A † 6.567 A 5.933 A	1.100 2.568 1.120	15 15 15	Nonparametric LSD test (data converted to rankits)	4.82
PCB 33 and PCB 33+53 (ng/g wet wt.)	Fish Mussel Clam	2.467 A † 1.777 A † 1.100 A	0.384 0.910 0.648	3 13 8	Nonparametric *t*-tests (data converted to rankits)	1.84
PCB 40 (ng/g wet wt.)	Mussel Clam Fish	2.653 A † 2.630 B † 2.360 B	0.604 1.972 2.077	15 15 15	Nonparametric *t*-tests (data converted to rankits)	4.74
PCB 42+37 (ng/g wet wt.)	Mussel Clam Fish	† 5.213 A † 4.397 A † 1.523 A	2.850 2.423 0.681	15 15 15	Nonparametric *t*-tests (data converted to rankits)	4.28
PCB 44 (ng/g wet wt.)	Clam Fish Mussel	† 3.117 A † 2.250 A † 1.587 A	0.906 1.578 0.440	15 15 15	LSD test (log-transformed data)	3.16
PCB 45 (ng/g wet wt.)	Mussel Fish Clam	5.613 A † 5.297 B † 2.187 B	0.492 4.974 0.813	15 15 15	Nonparametric *t*-tests (data converted to rankits)	8.46
PCB 46 (ng/g wet wt.)	Fish Clam Mussel	† 9.513 A † 2.127 A † 1.760 A	8.500 0.557 1.060	15 15 15	Nonparametric *t*-tests (data converted to rankits)	14.3
PCB 48+47 (ng/g wet wt.)	Mussel Fish Clam	† 7.733 A † 3.253 B † 3.003 B	1.243 1.931 1.028	15 15 15	Nonparametric LSD test (data converted to rankits)	4.16
PCB 49 and PCB 49+43 (ng/g wet wt.)	Mussel Clam Fish	3.587 A † 2.560 B † 2.263 B	0.813 1.478 1.006	15 15 15	*t*-tests (log-transformed data)	2.92
PCB 52 (ng/g wet wt.)	Mussel Fish Clam	14.067 A 3.207 A † 0.736 B	6.791 1.210 0.445	3 15 11	Nonparametric *t*-tests (data converted to rankits)	4.58
PCB 56+60 (ng/g wet wt.)	Mussel Clam Fish	† 5.393 A † 2.510 A † 0.743 B	3.029 1.411 0.459	15 15 15	Nonparametric LSD test (data converted to rankits)	4.42
PCB 63 (ng/g wet wt.)	Mussel Fish Clam	9.813 A † 5.250 B † 4.077 C	1.983 0.734 1.531	15 15 15	Nonparametric LSD test (data converted to rankits)	3.39
PCB 64+41+71 (ng/g wet wt.)	Clam Fish Mussel	† 2.471 A † 1.533 A †† 0.213 A	2.271 1.333 0.009	7 3 15	Nonparametric *t*-tests (data converted to rankits)	3.28

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Table A12 (Continued)						
Contaminant	**Organism**	**Mean Concentration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**LSD d_{min}[1]**
PCB 70+76 (ng/g wet wt.)	Clam Mussel Fish	† 2.897 A † 2.207 A † 1.297 A	1.368 1.383 0.599	15 15 15	Nonparametric *t*-tests (data converted to rankits)	2.45
PCB 74 (ng/g wet wt.)	Mussel Clam Fish	† 2.370 A † 2.137 AB † 0.613 B	1.307 1.376 0.487	15 15 15	Nonparametric *t*-tests (data converted to rankits)	2.74
PCB 82 (ng/g wet wt.)	Clam Mussel Fish	† 10.550 A † 1.660 B † 0.677 B	4.671 0.890 0.191	15 15 15	LSD test (log-transformed data)	6.82
PCB 83 (ng/g wet wt.)	Mussel Clam Fish	† 0.583 A †† 0.05 B †† 0.05 B	0.131 0 0	12 12 12	Nonparametric *t*-tests (data converted to rankits)	0.215
PCB 85 (ng/g wet wt.)	Mussel Fish Clam	4.860 A † 3.877 A † 1.553 B	1.537 1.276 0.631	15 15 15	Nonparametric *t*-tests (data converted to rankits)	1.98
PCB 87 (ng/g wet wt.)	Clam Mussel Fish	† 2.103 A † 1.960 A † 0.583 A	1.376 1.157 0.257	15 15 15	Nonparametric *t*-tests (data converted to rankits)	2.27
PCB 91 (ng/g wet wt.)	Clam Mussel Fish	† 1.637 A † 0.873 A † 0.700 A	0.938 0.270 0.313	15 15 15	Nonparametric *t*-tests (data converted to rankits)	1.33
PCB 92+84 and PCB 84 (ng/g wet wt.)	Mussel Fish Clam	† 5.613 A † 1.777 B † 1.627 AB	2.857 0.780 0.537	15 15 15	LSD test (log-transformed data)	4.04
PCB 95+66 (ng/g wet wt.)	Clam Mussel Fish	7.993 A † 6.132 B † 4.507 AB	2.434 3.507 0.521	15 14 15	*t*-tests (log-transformed data)	5.48
PCB 97 (ng/g wet wt.)	Mussel Clam Fish	† 3.533 A † 1.973 A † 0.947 A	1.362 1.006 0.537	15 15 15	Nonparametric *t*-tests (data converted to rankits)	1.70
PCB 99 (ng/g wet wt.)	Mussel Fish Clam	† 2.427 A † 0.263 A †† 0.05 A	1.854 0.155 0	15 15 15	Nonparametric *t*-tests (data converted to rankits)	2.89
PCB 100 (ng/g wet wt.)	Clam Mussel Fish	† 4.607 A † 2.277 A † 1.663 A	3.638 1.378 1.054	15 15 15	Nonparametric *t*-tests (data converted to rankits)	5.75
PCB 101 and PCB 101+89 (ng/g wet wt.)	Mussel Clam Fish	† 1.733 A † 1.367 B † 0.657 AB	0.742 1.317 0.305	15 15 15	Nonparametric *t*-tests (data converted to rankits)	2.14
PCB 110 and PCB 110+77 (ng/g wet wt.)	Mussel Clam Fish	† 1.847 A † 0.753 B † 0.213 B	0.765 0.543 0.163	15 15 15	Nonparametric *t*-tests (data converted to rankits)	1.35
						(Sheet 5 of 8)

Table A12 (Continued)

Contaminant	Organism	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 118 and PCB 118+149 (ng/g wet wt.)	Clam Mussel Fish	† 0.830 B † 0.810 A † 0.080 B	0.742 0.130 0.030	15 15 15	Nonparametric *t*-tests (data converted to rankits)	1.23
PCB 128 (ng/g wet wt.)	Mussel Clam Fish	† 3.473 A † 1.330 B † 0.617 B	1.991 0.902 0.386	15 15 15	Nonparametric *t*-tests (data converted to rankits)	3.07
PCB 131 (ng/g wet wt.)	Mussel Clam Fish	† 0.188 A †† 0.05 A †† 0.05 A	0.073 0 0	12 12 12	Nonparametric *t*-tests (data converted to rankits)	0.122
PCB 134+114 (ng/g wet wt.)	Clam Fish Mussel	0.867 A † 0.383 B † 0.379 B	0.050 0.105 0.126	12 12 12	Nonparametric *t*-tests (data converted to rankits)	0.290
PCB 135+144 (ng/g wet wt.)	Mussel Clam Fish	† 1.020 A † 0.600 AB † 0.210 B	0.339 0.221 0.078	15 15 15	Nonparametric *t*-tests (data converted to rankits)	0.605
PCB 136 (ng/g wet wt.)	Clam Mussel Fish	† 6.113 A † 2.163 A † 0.567 A	3.645 1.174 0.328	15 15 15	Nonparametric *t*-tests (data converted to rankits)	4.69
PCB 137+176 (ng/g wet wt.)	Clam Mussel Fish	† 0.697 A † 0.660 A † 0.277 A	0.445 0.351 0.191	15 15 15	Nonparametric *t*-tests (data converted to rankits)	0.806
PCB 141 (ng/g wet wt.)	Mussel Clam Fish	† 2.053 A † 1.983 A † 0.717 A	0.492 0.567 0.146	15 15 15	Nonparametric *t*-tests (data converted to rankits)	1.24
PCB 146 (ng/g wet wt.)	Mussel Clam Fish	† 2.917 A † 1.393 B † 0.087 B	0.616 0.534 0.037	15 15 15	Nonparametric *t*-tests (data converted to rankits)	1.38
PCB 149 (ng/g wet wt.)	Mussel Fish Clam	† 0.717 A † 0.088 B †† 0.05 B	0.176 0.038 0	12 12 12	Nonparametric *t*-tests (data converted to rankits)	0.302
PCB 151 (ng/g wet wt.)	Mussel Fish Clam	† 1.187 A † 0.390 A † 0.087 A	0.701 0.242 0.037	15 15 15	Nonparametric *t*-tests (data converted to rankits)	1.04
PCB 153+132+105 (ng/g wet wt.)	Mussel Clam Fish	† 4.213 A † 1.827 B † 0.433 B	0.814 0.781 0.223	15 15 15	*t*-tests (log-transformed data)	1.79
PCB 157+200 (ng/g wet wt.)	Mussel Clam Fish	† 2.600 A † 0.777 B † 0.623 B	1.541 0.503 0.341	15 15 15	Nonparametric *t*-tests (data converted to rankits)	2.17

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Table A12 (Continued)

Contaminant	Organism	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 158 (ng/g wet wt.)	Mussel Clam Fish	† 1.803 A † 0.493 AB † 0.340 B	0.846 0.304 0.197	15 15 15	Nonparametric *t*-tests (data converted to rankits)	1.18
PCB 163+138 (ng/g wet wt.)	Clam Mussel Fish	† 2.130 A † 1.203 A † 0.580 A	1.431 0.194 0.106	15 15 15	Nonparametric *t*-tests (data converted to rankits)	2.40
PCB 170+190 (ng/g wet wt.)	Clam Mussel Fish	3.440 A † 0.410 B †† 0.05 C	0.988 0.184 0	15 15 15	Nonparametric *t*-tests (data converted to rankits)	1.50
PCB 172+197 (ng/g wet wt.)	Mussel Clam Fish	† 2.833 A † 0.917 A † 0.847 A	1.695 0.607 0.508	15 15 15	Nonparametric *t*-tests (data converted to rankits)	2.20
PCB 173 (ng/g wet wt.)	Mussel Clam Fish	3.817 A †† 0.05 B †† 0.05 B	0.422 0 0	12 12 12	Nonparametric *t*-tests (data converted to rankits)	0.710
PCB 174 (ng/g wet wt.)	Mussel Fish Clam	† 0.463 A † 0.443 A † 0.100 A	0.212 0.268 0.050	15 15 15	Nonparametric *t*-tests (data converted to rankits)	0.510
PCB 175 (ng/g wet wt.)	Clam Fish Mussel	† 4.733 A † 0.350 A † 0.317 A	4.683 0.205 0.093	15 15 15	Nonparametric *t*-tests (data converted to rankits)	7.50
PCB 177 (ng/g wet wt.)	Mussel Clam Fish	† 2.207 A † 1.357 AB † 0.283 B	1.132 0.917 0.159	15 15 15	Nonparametric *t*-tests (data converted to rankits)	1.77
PCB 178 (ng/g wet wt.)	Mussel Fish Clam	† 4.150 A † 1.240 A † 1.090 A	2.437 0.605 0.716	15 15 15	Nonparametric *t*-tests (data converted to rankits)	3.18
PCB 180 (ng/g wet wt.)	Mussel Fish Clam	† 1.213 A † 0.683 B †† 0.120 B	0.762 0.402 0.020	15 15 15	Nonparametric *t*-tests (data converted to rankits)	1.18
PCB 183 (ng/g wet wt.)	Mussel Fish Clam	† 0.870 A † 0.510 AB † 0.160 B	0.368 0.314 0.110	15 15 15	Nonparametric *t*-tests (data converted to rankits)	0.717
PCB 185 (ng/g wet wt.)	Clam Fish Mussel	† 1.370 A † 0.237 A †† 0.05 A	1.194 0.127 0	15 15 15	Nonparametric *t*-tests (data converted to rankits)	1.87
PCB 187+182 (ng/g wet wt.)	Mussel Clam Fish	† 1.643 A † 1.040 AB † 0.493 B	0.841 0.624 0.295	15 15 15	Nonparametric *t*-tests (data converted to rankits)	1.36
PCB 189 (ng/g wet wt.)	Mussel Clam Fish	† 0.288 A †† 0.05 A †† 0.05 A	0.140 0 0	12 12 12	Nonparametric *t*-tests (data converted to rankits)	0.236

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Table A12 (Concluded)

Contaminant	Organism	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[a]
PCB 191 (ng/g wet wt.)	Mussel	† 0.303 A	0.126	15	Nonparametric *t*-tests (data converted to rankits)	0.243
	Fish	† 0.170 A	0.082	15		
	Clam	†† 0.048 A	0.002	15		
PCB 193 (ng/g wet wt.)	Clam	† 0.703 A	0.484	15	Nonparametric *t*-tests (data converted to rankits)	0.752
	Mussel	† 0.190 A	0.096	15		
	Fish	† 0.190 A	0.095	15		
PCB 194 (ng/g wet wt.)	Mussel	† 0.857 A	0.652	15	Nonparametric *t*-tests (data converted to rankits)	0.987
	Fish	† 0.370 A	0.219	15		
	Clam	† 0.140 A	0.090	15		
PCB 198 (ng/g wet wt.)	Clam	† 1.963 A	1.556	15	Nonparametric *t*-tests (data converted to rankits)	2.63
	Mussel	† 0.960 A	0.806	15		
	Fish	† 0.350 A	0.270	15		
PCB 199 (ng/g wet wt.)	Clam	† 1.250 A	0.874	15	Nonparametric *t*-tests (data converted to rankits)	1.42
	Mussel	† 0.963 A	0.576	15		
	Fish	†† 0.05 A	0	15		
PCB 201 (ng/g wet wt.)	Clam	† 1.280 A	0.738	15	Nonparametric *t*-tests (data converted to rankits)	1.14
	Mussel	† 0.953 A	0.644	15		
	Fish	† 0.540 A	0.327	15		
PCB 202+171 (ng/g wet wt.)	Mussel	† 1.257 AB	0.937	15	Nonparametric *t*-tests (data converted to rankits)	1.56
	Clam	† 0.960 A	0.346	15		
	Fish	† 0.087 B	0.037	15		
PCB 203+196 (ng/g wet wt.)	Clam	† 3.293 A	1.856	15	Nonparametric *t*-tests (data converted to rankits)	2.52
	Mussel	† 1.413 A	0.927	15		
	Fish	† 0.320 A	0.249	15		
PCB 205 (ng/g wet wt.)	Clam	† 1.603 A	1.446	15	Nonparametric *t*-tests (data converted to rankits)	2.23
	Mussel	† 0.407 A	0.222	15		
	Fish	† 0.223 A	0.123	15		
PCB 207 (ng/g wet wt.)	Mussel	† 1.257 A	0.696	15	Nonparametric *t*-tests (data converted to rankits)	1.08
	Fish	† 0.320 A	0.270	15		
	Clam	† 0.193 A	0.143	15		
PCB 208+195 (ng/g wet wt.)	Clam	† 3.003 A	2.200	15	Nonparametric *t*-tests (data converted to rankits)	3.78
	Mussel	† 1.480 A	1.430	15		
	Fish	† 0.120 A	0.070	15		
Lipid (percent wet wt.)	Mussel	2.209 A	0.101	15	Nonparametric *t*-tests (data converted to rankits)	0.439
	Clam	1.776 AB	0.254	15		
	Fish	1.381 B	0.210	15		

Table A13.
Berkeley Flats Reference Sediment: Descriptive Statistics and Statistical Comparisons of Contaminant Bioaccumulation and Lipid from 28-Day Exposures to Bedded Sediment (BS) vs. 28-Day Exposures to 50 mg/L Suspended Sediment (S50)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
Acenaphthene (ng/g wet wt.)	Mussel	BS S50	†† 0.766[2] † 1.653	0.078 0.816	6 6	Wilcoxon Rank-Sum test	1.83
	Clam	BS S50	† 1.118 † 0.932	0.644 0.467	6 6	*t*-test (log-transformed data)	1.77
	Fish	BS S50	† 1.363 † 0.481	0.741 0.160	6 6	*t*-test (log-transformed data)	1.69
	All	BS S50	† 1.082 † 1.022	0.314 0.321	18 18	*t*-test (log-transformed data)	0.912
Acenaphthylene (ng/g wet wt.)	Clam	BS S50	†† 0.113 † 0.314 *[3]	0.018 0.069	6 6	*t*-test	0.160
	All	BS S50	†† 0.133 † 0.203	0.014 0.032	18 18	*t*-test (log-transformed data)	0.071
Anthracene (ng/g wet wt.)	Mussel	BS S50	†† 0.873 † 2.500	0.127 1.500	6 6	Wilcoxon Rank-Sum test	3.35
	Clam	BS S50	†† 0.726 † 0.417	0.174 0.133	6 6	*t*-test	0.487
	All	BS S50	†† 0.579 † 1.024	0.102 0.536	18 18	Wilcoxon Rank-Sum test	1.11
Benz[a]anthracene (ng/g wet wt.)	Mussel	BS S50	†† 0.651 † 2.031	0.121 0.749	6 6	*t*-test	1.69
	Clam	BS S50	5.165 4.028	0.765 0.185	6 6	*t*-test	1.75
	Fish	BS S50	† 0.252 † 0.355	0.148 0.136	6 6	Wilcoxon Rank-Sum test	0.447
	All	BS S50	† 2.023 † 2.138	0.594 0.439	18 18	Wilcoxon Rank-Sum test	1.50
Benzo[a]pyrene (ng/g wet wt.)	Mussel	BS S50	†† 0.208 † 0.580	0.024 0.218	6 6	*t*-test (log-transformed data)	0.739
	Clam	BS S50	4.480 5.258	0.296 0.491	6 6	Wilcoxon Rank-Sum test	1.28
	Fish	BS S50	† 0.219 †† 0.097	0.135 0.013	6 6	Wilcoxon Rank-Sum test	0.301
	All	BS S50	† 1.636 † 2.031	0.513 0.574	18 18	Wilcoxon Rank-Sum test	1.57

[1] Minimum significant difference that can be detected by LSD test on untransformed data.
[2] † Mean includes at least one concentration less than DL and set equal to DL/10;
†† All concentrations less than DL and set equal to DL/10.
Organisms in which all observations were less than DL are not included in the statistical comparisons.
[3] * Indicates a treatment that is significantly greater than the other treatment (two-tailed test, $\alpha/2 = 0.025$).

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Table A13 (continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
Benzo[b]fluoranthene (ng/g wet wt.)	Mussel	BS S50	† 1.951 † 3.186	0.698 0.874	6 6	*t*-test	2.49
	Clam	BS S50	7.398 9.985 *	0.767 0.789	6 6	*t*-test	2.45
	All	BS S50	† 3.146 † 4.426	0.819 1.067	18 18	Wilcoxon Rank-Sum test	2.73
Benzo[k]fluoranthene (ng/g wet wt.)	Mussel	BS S50	† 0.395 † 0.452	0.155 0.196	6 6	Wilcoxon Rank-Sum test	0.556
	Clam	BS S50	† 2.522 † 1.810	0.827 1.004	6 6	*t*-test	2.90
	All	BS S50	† 1.002 † 0.789	0.372 0.367	18 18	Wilcoxon Rank-Sum test	1.06
Benzo[g,h,i]-perylene (ng/g wet wt.)	Mussel	BS S50	† 0.797 † 0.469	0.685 0.225	6 6	Wilcoxon Rank-Sum test	1.61
	Clam	BS S50	4.538 5.910	0.441 0.475	6 6	*t*-test	1.44
	Fish	BS S50	†† 0.088 † 0.221	0.009 0.113	6 6	Wilcoxon Rank-Sum test	0.252
	All	BS S50	† 1.808 † 2.200	0.538 0.659	18 18	Wilcoxon Rank-Sum test	1.73
Chrysene (ng/g wet wt.)	Mussel	BS S50	3.185 † 4.505	0.373 1.261	6 6	Wilcoxon Rank-Sum test	2.93
	Clam	BS S50	4.253 5.262	0.459 0.243	6 6	*t*-test	1.16
	All	BS S50	† 2.510 † 3.292	0.466 0.682	18 18	Wilcoxon Rank-Sum test	1.68
Dibenz[a,h]anthracene (ng/g wet wt.)	Clam	BS S50	† 0.644 † 0.594	0.361 0.217	6 6	*t*-test (log-transformed data)	0.938
	All	BS S50	† 0.402 † 0.409	0.129 0.089	18 18	*t*-test (log-transformed data)	0.318
Dibenzothiophene (ng/g wet wt.)	Mussel	BS S50	†† 0.631 † 4.576	0.095 3.402	6 6	*t*-test (log-transformed data)	7.60
	Clam	BS S50	†† 0.368 † 0.379	0.076 0.108	6 6	*t*-test	0.294
	All	BS S50	†† 0.377 † 1.702	0.062 1.175	18 18	Wilcoxon Rank-Sum test	2.45

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Table A13 (continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
Fluoranthene (ng/g wet wt.)	Mussel	BS S50	6.080 10.317 *	0.715 0.635	6 6	*t*-test	2.13
	Clam	BS S50	8.915 13.033 *	1.041 0.551	6 6	*t*-test	2.62
	All	BS S50	† 5.033 † 7.824 *	0.974 1.373	18 18	Wilcoxon Rank-Sum test	3.42
Fluorene (ng/g wet wt.)	Mussel	BS S50	† 2.272 † 3.271	0.948 1.241	6 6	*t*-test	3.73
	Clam	BS S50	† 5.280 † 1.998	1.393 1.054	6 6	*t*-test	3.89
	Fish	BS S50	† 1.757 † 0.402	0.769 0.192	6 6	*t*-test	1.77
	All	BS S50	† 3.103 † 1.890	0.692 0.587	18 18	*t*-test (log-transformed data)	1.92
Indeno[1,2,3-cd]pyrene (ng/g wet wt.)	Mussel	BS S50	† 0.543 †† 0.307	0.228 0.050	6 6	*t*-test (log-transformed data)	0.519
	Clam	BS S50	4.148 4.223	0.305 0.434	6 6	*t*-test	1.18
	All	BS S50	† 1.591 † 1.542	0.457 0.480	18 18	Wilcoxon Rank-Sum test	1.35
Naphthalene (ng/g wet wt.)	Mussel	BS S50	48.733 44.133	4.594 4.360	6 6	*t*-test	14.1
	Clam	BS S50	39.337 14.627	10.082 4.026	6 6	*t*-test	24.2
	Fish	BS S50	19.487 † 13.820	3.773 3.145	6 6	*t*-test	10.9
	All	BS S50	35.852 † 24.193	4.709 4.015	18 18	*t*-test	12.6
Phenanthrene (ng/g wet wt.)	Mussel	BS S50	24.983 30.600 *	1.561 1.871	6 6	*t*-test (log-transformed data)	5.43
	Clam	BS S50	20.200 8.838	5.156 1.298	6 6	*t*-test	11.8
	Fish	BS S50	7.342 † 6.463	1.599 1.810	6 6	*t*-test	5.38
	All	BS S50	17.508 † 15.300	2.522 2.787	18 18	*t*-test (log-transformed data)	7.64

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Table A13 (continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
Pyrene (ng/g wet wt.)	Mussel	BS	7.185	1.039	6	*t*-test	3.77
		S50	16.000 *	1.338	6		
	Clam	BS	8.908	0.916	6	*t*-test	2.53
		S50	13.750 *	0.671	6		
	All	BS	† 5.394	1.022	18	Wilcoxon Rank-Sum test	4.15
		S50	† 9.951 *	1.767	18		
Cd (µg/g dry wt.)	Mussel	BS	3.060	0.222	6	*t*-test	0.551
		S50	3.778 *	0.110	6		
	Clam	BS	0.401	0.032	6	*t*-test	0.078
		S50	0.403	0.014	6		
	Fish	BS	0.397	0.018	6	Wilcoxon Rank-Sum test	0.045
		S50	0.390	0.008	6		
	All	BS	1.286	0.312	18	Wilcoxon Rank-Sum test	1.01
		S50	1.524	0.388	18		
Cr (µg/g dry wt.)	Mussel	BS	0.718	0.085	6	*t*-test	0.256
		S50	0.615	0.077	6		
	Clam	BS	8.150	0.666	6	*t*-test	1.63
		S50	7.833	0.300	6		
	Fish	BS	0.843	0.167	6	*t*-test (log-transformed data)	0.434
		S50	1.300 *	0.100	6		
	All	BS	3.237	0.870	18	Wilcoxon Rank-Sum test	2.40
		S50	3.249	0.796	18		
Hg (µg/g dry wt.)	Mussel	BS	0.145	0.009	6	*t*-test	0.026
		S50	0.162	0.007	6		
	Clam	BS	0.144	0.008	6	*t*-test	0.024
		S50	0.160	0.007	6		
	Fish	BS	0.260	0.011	6	*t*-test	0.024
		S50	0.250	0.002	6		
	All	BS	0.183	0.014	18	Wilcoxon Rank-Sum test	0.036
		S50	0.191	0.011	18		
TBT (ng/g wet wt.)	Mussel	BS	22.633	2.109	6	*t*-test	5.63
		S50	20.667	1.389	6		
	Clam	BS	20.250	1.630	6	*t*-test	4.08
		S50	16.933	0.829	6		
	Fish	BS	12.140	2.394	5	*t*-test	5.63
		S50	8.933	1.116	6		
	All	BS	18.706	1.546	17	*t*-test	4.14
		S50	15.511	1.337	18		

(Sheet 4 of 18)

Table A13 (continued)							
Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
DBT (ng/g wet wt.)	Mussel	BS S50	10.117 8.467	0.928 1.163	6 6	*t*-test	3.32
	Clam	BS S50	† 1.592 2.500	0.443 0.124	6 6	*t*-test	1.03
	All	BS S50	† 4.197 † 3.729	1.153 0.919	17 18	Wilcoxon Rank-Sum test	2.98
MBT (ng/g wet wt.)	Clam	BS S50	†† 0.878 † 5.152	0.075 2.042	6 6	*t*-test	4.55
	All	BS S50	†† 0.534 † 1.980	0.070 0.840	17 18	Wilcoxon Rank-Sum test	1.77
PCB 1 (ng/g wet wt.)	Clam	BS S50	19.150 18.067	14.450 6.172	2 6	Wilcoxon Rank-Sum test	32.2
	Fish	BS S50	22.833 524.083	4.355 497.185	6 6	Wilcoxon Rank-Sum test	1108
	All	BS S50	21.913 271.075	4.241 249.014	8 12	Wilcoxon Rank-Sum test	647
PCB 8+5 (ng/g wet wt.)	Mussel	BS S50	5.683 † 5.783	0.666 1.506	6 6	*t*-test	3.67
	Clam	BS S50	† 1.683 * † 0.192	0.530 0.142	6 6	*t*-test	1.22
	Fish	BS S50	† 0.158 † 37.750	0.108 34.964	6 6	*t*-test (log-transformed data)	77.9
	All	BS S50	† 2.508 † 14.575	0.626 11.670	18 18	Wilcoxon Rank-Sum test	23.7
PCB 17 (ng/g wet wt.)	Mussel	BS S50	† 0.508 † 0.617	0.201 0.356	6 6	Wilcoxon Rank-Sum test	0.912
	Clam	BS S50	† 1.550 4.183	0.918 0.746	6 6	Wilcoxon Rank-Sum test	2.64
	Fish	BS S50	† 0.608 † 0.533	0.132 0.369	6 6	*t*-test (log-transformed data)	0.873
	All	BS S50	† 0.889 † 1.778	0.318 0.501	18 18	Wilcoxon Rank-Sum test	1.21

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Table A13 (continued)

Contaminant	Organ-ism	Treat-ment	Mean Concen-tration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 18 (ng/g wet wt.)	Mussel	BS S50	2.700 † 2.300	0.413 0.543	6 6	*t*-test	1.52
	Clam	BS S50	† 0.617 † 0.733	0.366 0.226	6 6	*t*-test (log-transformed data)	0.959
	Fish	BS S50	† 0.142 † 40.533	0.092 40.254	6 6	Wilcoxon Rank-Sum test	89.7
	All	BS S50	† 1.153 † 14.522	0.321 13.372	18 18	Wilcoxon Rank-Sum test	27.2
PCB 19 (ng/g wet wt.)	Mussel	BS S50	† 0.142 †† 0.050	0.092 0	6 6	Wilcoxon Rank-Sum test	0.204
	Clam	BS S50	† 0.725 † 0.683	0.310 0.208	6 6	Wilcoxon Rank-Sum test	0.831
	Fish	BS S50	† 0.125 † 20.450	0.075 20.270	6 6	Wilcoxon Rank-Sum test	45.2
	All	BS S50	† 0.331 † 7.061	0.124 6.750	18 18	Wilcoxon Rank-Sum test	13.7
PCB 22 and PCB 22+51 (ng/g wet wt.)	Mussel	BS S50	4.483 4.617	0.367 0.751	6 6	*t*-test	1.86
	Clam	BS S50	† 1.750 † 1.867	0.509 0.811	6 6	Wilcoxon Rank-Sum test	2.13
	Fish	BS S50	†† 0.200 † 9.583	0 9.383	6 6	Wilcoxon Rank-Sum test	20.9
	All	BS S50	† 2.144 † 5.356	0.472 3.058	18 18	Wilcoxon Rank-Sum test	6.29
PCB 25 (ng/g wet wt.)	Mussel	BS S50	8.700 7.750	2.151 1.726	6 6	*t*-test (log-transformed data)	6.15
	Clam	BS S50	1.950 * † 0.233	0.492 0.119	6 6	*t*-test	1.13
	Fish	BS S50	† 0.142 † 6.583	0.092 6.287	6 6	Wilcoxon Rank-Sum test	14.0
	All	BS S50	† 3.597 † 4.856	1.130 2.193	18 18	Wilcoxon Rank-Sum test	5.01

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Table A13 (continued)							
Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 26 (ng/g wet wt.)	Mussel	BS S50	3.267 † 2.642	0.347 0.609	6 6	*t*-test	1.56
	Clam	BS S50	† 1.642 4.067	0.648 0.950	6 6	Wilcoxon Rank-Sum test	2.56
	Fish	BS S50	† 0.433 † 17.617	0.302 17.457	6 6	Wilcoxon Rank-Sum test	38.9
	All	BS S50	† 1.781 † 8.108	0.376 5.717	18 18	Wilcoxon Rank-Sum test	11.6
PCB 27 (ng/g wet wt.)	Clam	BS S50	†† 0.050 † 0.350	0 0.190	2 6	Wilcoxon Rank-Sum test	0.850
	Fish	BS S50	1.000 14.350	0.093 13.530	6 6	Wilcoxon Rank-Sum test	30.1
	All	BS S50	† 0.763 † 7.350	0.170 6.787	8 12	Wilcoxon Rank-Sum test	17.6
PCB 29 (ng/g wet wt.)	Mussel	BS S50	†† 0.050 † 0.675	0 0.625	6 6	Wilcoxon Rank-Sum test	1.39
	All	BS S50	†† 0.050 † 0.258	0 0.208	18 18	Wilcoxon Rank-Sum test	0.423
PCB 31+28 (ng/g wet wt.)	Mussel	BS S50	12.700 14.050	2.706 1.430	5 6	*t*-test	6.58
	Clam	BS S50	6.083 * † 0.517	1.583 0.298	6 6	*t*-test	3.59
	Fish	BS S50	2.683 7.733	0.549 5.421	6 6	*t*-test (log-transformed data)	12.1
	All	BS S50	6.829 † 7.433	1.369 2.211	17 18	*t*-test (log-transformed data)	5.36
PCB 32+16 (ng/g wet wt.)	Mussel	BS S50	4.350 4.400	0.616 0.659	6 6	*t*-test	2.01
	Clam	BS S50	† 2.333 † 4.733	0.729 1.566	6 6	*t*-test	3.85
	Fish	BS S50	9.983 † 7.558	0.961 1.618	6 6	*t*-test	4.19
	All	BS S50	† 5.556 † 5.564	0.892 0.811	18 18	*t*-test	2.45
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Table A13 (continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 40 (ng/g wet wt.)	Mussel	BS S50	1.933 1.567	0.407 0.314	6 6	*t*-test	1.15
	Clam	BS S50	† 0.933 * †† 0.050	0.300 0	6 6	Wilcoxon Rank-Sum test	0.670
	Fish	BS S50	† 0.267 † 5.367	0.139 5.207	6 6	Wilcoxon Rank-Sum test	11.6
	All	BS S50	† 1.044 † 2.328	0.234 1.721	18 18	Wilcoxon Rank-Sum test	3.53
PCB 42+37 (ng/g wet wt.)	Mussel	BS S50	† 0.300 † 1.267	0.220 0.492	6 6	*t*-test (log-transformed data)	1.20
	Clam	BS S50	† 0.317 † 0.675	0.181 0.290	6 6	*t*-test	0.761
	Fish	BS S50	†† 0.050 † 1.308	0 1.258	6 6	Wilcoxon Rank-Sum test	2.80
	All	BS S50	† 0.222 † 1.083	0.094 0.438	18 18	Wilcoxon Rank-Sum test	0.911
PCB 44 (ng/g wet wt.)	Mussel	BS S50	† 0.600 † 1.433	0.308 0.615	6 6	*t*-test	1.53
	Clam	BS S50	5.550 * † 0.950	1.771 0.354	6 6	*t*-test	4.02
	Fish	BS S50	† 0.217 † 4.275	0.106 3.948	6 6	*t*-test (log-transformed data)	8.80
	All	BS S50	† 2.122 † 2.219	0.815 1.305	18 18	Wilcoxon Rank-Sum test	3.13
PCB 45 (ng/g wet wt.)	Mussel	BS S50	4.867 6.083	0.533 0.247	6 6	*t*-test	1.31
	Clam	BS S50	† 2.650 * † 0.200	0.834 0.095	6 6	*t*-test	1.87
	Fish	BS S50	†† 0.050 † 12.525	0 12.475	6 6	Wilcoxon Rank-Sum test	27.8
	All	BS S50	† 2.522 † 6.269	0.569 4.093	18 18	Wilcoxon Rank-Sum test	8.40

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Table A13 (continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 46 (ng/g wet wt.)	Mussel	BS S50	†† 0.050 † 0.367	0 0.225	6 6	Wilcoxon Rank-Sum test	0.502
	Clam	BS S50	† 0.650 † 2.233	0.334 0.810	6 6	*t*-test	1.95
	Fish	BS S50	† 0.533 † 21.567	0.333 21.367	6 6	Wilcoxon Rank-Sum test	47.6
	All	BS S50	† 0.411 † 8.056	0.161 7.087	18 18	Wilcoxon Rank-Sum test	14.4
PCB 48+47 (ng/g wet wt.)	Mussel	BS S50	† 6.738 9.433	2.411 0.651	4 6	*t*-test	4.78
	Clam	BS S50	† 2.925 † 1.225	1.648 0.374	6 6	*t*-test	3.77
	Fish	BS S50	0.867 † 5.417	0.123 4.880	6 6	Wilcoxon Rank-Sum test	10.9
	All	BS S50	† 3.106 † 5.358	0.989 1.747	16 18	Wilcoxon Rank-Sum test	4.23
PCB 49 and PCB 49+43 (ng/g wet wt.)	Mussel	BS S50	2.667 2.617	0.300 0.209	6 6	*t*-test	0.814
	Clam	BS S50	† 1.467 * † 0.050	0.455 0	6 6	Wilcoxon Rank-Sum test	1.01
	Fish	BS S50	† 0.842 † 3.150	0.178 2.503	6 6	Wilcoxon Rank-Sum test	5.59
	All	BS S50	† 1.658 † 1.939	0.257 0.852	18 18	Wilcoxon Rank-Sum test	1.81
PCB 52 (ng/g wet wt.)	Clam	BS S50	†† 0.050 † 0.142	0 0.092	2 6	Wilcoxon Rank-Sum test	0.410
	Fish	BS S50	1.417 4.200	0.196 2.934	6 6	Wilcoxon Rank-Sum test	6.55
	All	BS S50	† 1.075 † 2.171	0.266 1.527	8 12	*t*-test (log-transformed data)	3.99
PCB 56+60 (ng/g wet wt.)	Mussel	BS S50	0.750 † 0.700	0.092 0.312	6 6	*t*-test	0.724
	Clam	BS S50	† 0.317 † 0.692	0.169 0.168	6 6	*t*-test	0.531
	Fish	BS S50	†† 0.050 † 0.958	0 0.908	6 6	Wilcoxon Rank-Sum test	2.02
	All	BS S50	† 0.372 † 0.783	0.092 0.307	18 18	Wilcoxon Rank-Sum test	0.651

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Table A13 (continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 63 (ng/g wet wt.)	Mussel	BS S50	8.433 6.367	2.257 1.424	6 6	*t*-test	5.95
	Clam	BS S50	3.367 * 0.967	0.884 0.071	6 6	*t*-test	1.98
	Fish	BS S50	5.100 † 3.558	0.656 1.010	6 6	*t*-test	2.68
	All	BS S50	5.633 * † 3.631	0.937 0.765	18 18	*t*-test (log-transformed data)	2.46
PCB 70+76 (ng/g wet wt.)	Clam	BS S50	† 0.333 † 0.425	0.088 0.181	6 6	*t*-test	0.449
	Fish	BS S50	† 0.625 † 1.767	0.314 1.463	6 6	Wilcoxon Rank-Sum test	3.34
	All	BS S50	† 0.386 † 0.797	0.111 0.491	18 18	Wilcoxon Rank-Sum test	1.02
PCB 74 (ng/g wet wt.)	Mussel	BS S50	† 0.558 † 0.742	0.255 0.200	6 6	*t*-test	0.723
	Clam	BS S50	†† 0.050 † 0.275	0 0.225	6 6	Wilcoxon Rank-Sum test	0.501
	Fish	BS S50	† 0.233 † 1.275	0.119 1.225	6 6	Wilcoxon Rank-Sum test	2.74
	All	BS S50	† 0.281 † 0.764	0.102 0.407	18 18	Wilcoxon Rank-Sum test	0.853
PCB 82 (ng/g wet wt.)	Mussel	BS S50	† 0.217 † 0.400	0.106 0.235	6 6	Wilcoxon Rank-Sum test	0.574
	Clam	BS S50	† 6.025 † 1.950	1.705 0.865	6 6	*t*-test	4.26
	Fish	BS S50	† 0.375 † 0.525	0.148 0.103	6 6	*t*-test	0.401
	All	BS S50	† 2.206 † 0.958	0.847 0.330	18 18	Wilcoxon Rank-Sum test	1.85
PCB 83 (ng/g wet wt.)	Mussel	BS S50	† 0.408 † 0.758	0.161 0.193	6 6	*t*-test	0.561
	All	BS S50	† 0.169 † 0.286	0.065 0.101	18 18	Wilcoxon Rank-Sum test	0.244

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Table A13 (continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 85 (ng/g wet wt.)	Mussel	BS S50	2.483 2.367	0.277 0.291	6 6	*t*-test	0.895
	Clam	BS S50	0.817 † 0.608	0.095 0.121	6 6	*t*-test	0.343
	Fish	BS S50	1.667 † 1.375	0.152 0.318	6 6	*t*-test	0.786
	All	BS S50	1.656 † 1.450	0.195 0.224	18 18	*t*-test	0.603
PCB 87 (ng/g wet wt.)	Mussel	BS S50	† 0.375 † 0.325	0.152 0.123	6 6	Wilcoxon Rank-Sum test	0.436
	Clam	BS S50	†† 0.050 † 0.208	0 0.158	6 6	Wilcoxon Rank-Sum test	0.353
	Fish	BS S50	† 0.342 †† 0.050	0.136 0	6 6	*t*-test	0.304
	All	BS S50	† 0.256 † 0.194	0.073 0.068	18 18	Wilcoxon Rank-Sum test	0.204
PCB 91 (ng/g wet wt.)	Mussel	BS S50	† 0.608 † 0.567	0.281 0.223	6 6	*t*-test	0.800
	Clam	BS S50	† 0.125 †† 0.050	0.075 0	6 6	Wilcoxon Rank-Sum test	0.167
	Fish	BS S50	† 0.142 † 0.675	0.092 0.625	6 6	Wilcoxon Rank-Sum test	1.41
	All	BS S50	† 0.292 † 0.431	0.110 0.218	18 18	Wilcoxon Rank-Sum test	0.496
PCB 92+84 (ng/g wet wt.)	Mussel	BS S50	† 1.475 † 1.308	0.417 0.354	6 6	*t*-test	1.22
	Clam	BS S50	† 0.775 † 1.217	0.371 0.382	6 6	*t*-test	1.19
	Fish	BS S50	† 0.175 † 1.250	0.125 1.057	6 6	Wilcoxon Rank-Sum test	2.37
	All	BS S50	† 0.808 † 1.258	0.221 0.369	18 18	Wilcoxon Rank-Sum test	0.874

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Table A13 (continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 95+66 (ng/g wet wt.)	Mussel	BS	† 1.850	1.465	5	Wilcoxon Rank-Sum test	3.60
		S50	† 1.300	0.800	6		
	Clam	BS	5.167	1.035	6	*t*-test	2.51
		S50	3.533	0.439	6		
	Fish	BS	4.417	0.264	6	*t*-test	1.70
		S50	† 3.433	0.717	6		
	All	BS	† 3.926	0.634	17	*t*-test	1.56
		S50	† 2.756	0.441	18		
PCB 97 (ng/g wet wt.)	Mussel	BS	† 1.450	0.536	6	*t*-test	1.63
		S50	† 1.567	0.497	6		
	All	BS	† 0.550	0.228	18	Wilcoxon Rank-Sum test	0.656
		S50	† 0.589	0.229	18		
PCB 99 (ng/g wet wt.)	Mussel	BS	†† 0.050	0	6	Wilcoxon Rank-Sum test	0.501
		S50	† 0.275	0.225	6		
	Fish	BS	†† 0.050	0	6	Wilcoxon Rank-Sum test	0.390
		S50	† 0.225	0.175	6		
	All	BS	†† 0.050	0	18	Wilcoxon Rank-Sum test	0.188
		S50	† 0.183	0.092	18		
PCB 100 (ng/g wet wt.)	Mussel	BS	†† 0.050	0	6	Wilcoxon Rank-Sum test	0.501
		S50	† 0.275	0.225	6		
	Fish	BS	†† 0.050	0	6	Wilcoxon Rank-Sum test	5.78
		S50	† 2.642	2.592	6		
	All	BS	†† 0.050	0	18	Wilcoxon Rank-Sum test	1.75
		S50	† 0.989	0.863	18		
PCB 101 and PCB 101+89 (ng/g wet wt.)	Mussel	BS	† 0.683	0.214	6	*t*-test	0.640
		S50	† 0.567	0.190	6		
PCB 101 and PCB 101+89 (continued)	Fish	BS	†† 0.050	0	6	Wilcoxon Rank-Sum test	0.761
		S50	† 0.392	0.342	6		
	All	BS	† 0.261	0.099	18	Wilcoxon Rank-Sum test	0.337
		S50	† 0.336	0.133	18		
	Mussel	BS	† 0.917	0.289	6	*t*-test	0.902
		S50	† 0.750	0.283	6		
	Clam	BS	† 0.450	0.253	6	Wilcoxon Rank-Sum test	0.564
		S50	†† 0.050	0	6		
	All	BS	† 0.472	0.148	18	Wilcoxon Rank-Sum test	0.386
		S50	† 0.283	0.120	18		

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Table A13 (continued)							
Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 118 (ng/g wet wt.)	Mussel	BS S50	1.000 † 0.908	0.157 0.211	6 6	*t*-test	0.586
	Clam	BS S50	† 0.142 †† 0.050	0.092 0	6 6	Wilcoxon Rank-Sum test	0.204
	All	BS S50	† 0.397 † 0.336	0.118 0.118	18 18	Wilcoxon Rank-Sum test	0.340
PCB 128 (ng/g wet wt.)	Mussel	BS S50	† 1.350 † 1.033	0.425 0.498	6 6	*t*-test	1.46
	All	BS S50	† 0.483 † 0.378	0.199 0.192	18 18	Wilcoxon Rank-Sum test	0.563
PCB 131 (ng/g wet wt.)	Mussel	BS S50	† 0.142 † 0.233	0.092 0.119	6 6	Wilcoxon Rank-Sum test	0.334
	All	BS S50	† 0.081 † 0.111	0.031 0.043	18 18	Wilcoxon Rank-Sum test	0.107
PCB 134+114 (ng/g wet wt.)	Mussel	BS S50	† 0.208 † 0.550	0.158 0.182	6 6	*t*-test	0.537
	Clam	BS S50	0.833 0.900	0.080 0.063	6 6	*t*-test	0.228
	Fish	BS S50	† 0.558 * † 0.208	0.107 0.158	6 6	*t*-test (log-transformed data)	0.426
	All	BS S50	† 0.533 † 0.553	0.090 0.104	18 18	Wilcoxon Rank-Sum test	0.279
PCB 135+144 (ng/g wet wt.)	Mussel	BS S50	† 0.867 † 0.717	0.667 0.356	6 6	Wilcoxon Rank-Sum test	1.68
	Clam	BS S50	† 0.467 * †† 0.100	0.307 0	6 6	Wilcoxon Rank-Sum test	0.685
	All	BS S50	† 0.478 † 0.306	0.242 0.132	18 18	Wilcoxon Rank-Sum test	0.560
PCB 136 (ng/g wet wt.)	Mussel	BS S50	† 0.208 †† 0.050	0.158 0	6 6	Wilcoxon Rank-Sum test	0.353
	All	BS S50	† 0.103 †† 0.050	0.053 0	18 18	Wilcoxon Rank-Sum test	0.107
PCB 137+176 (ng/g wet wt.)	Mussel	BS S50	† 0.325 † 0.408	0.126 0.191	6 6	*t*-test	0.510
	All	BS S50	† 0.142 † 0.169	0.050 0.073	18 18	Wilcoxon Rank-Sum test	0.180

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Table A13 (continued)							
Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 141 (ng/g wet wt.)	Mussel	BS S50	† 1.183 † 2.383	0.595 0.733	6 6	*t*-test	2.10
	Clam	BS S50	† 2.333 † 0.592	0.749 0.289	6 6	*t*-test	1.79
	Fish	BS S50	1.250 * † 0.442	0.128 0.185	6 6	*t*-test	0.502
	All	BS S50	† 1.589 † 1.139	0.328 0.332	18 18	*t*-test (log-transformed data)	0.948
PCB 146 (ng/g wet wt.)	Mussel	BS S50	† 1.583 † 4.083	0.818 0.777	6 6	*t*-test	2.52
	Clam	BS S50	† 3.050 * †† 0.050	0.970 0	6 6	Wilcoxon Rank-Sum test	2.16
	All	BS S50	† 1.561 † 1.394	0.496 0.521	18 18	Wilcoxon Rank-Sum test	1.46
PCB 149 (ng/g wet wt.)	Mussel	BS S50	† 0.767 † 0.667	0.268 0.250	6 6	*t*-test	0.815
	All	BS S50	† 0.289 † 0.281	0.117 0.105	18 18	Wilcoxon Rank-Sum test	0.320
PCB 151 (ng/g wet wt.)	Mussel	BS S50	†† 0.050 † 0.267	0 0.139	6 6	Wilcoxon Rank-Sum test	0.311
	Clam	BS S50	† 0.142 †† 0.050	0.092 0	6 6	Wilcoxon Rank-Sum test	0.204
	All	BS S50	† 0.081 † 0.122	0.031 0.050	18 18	Wilcoxon Rank-Sum test	0.119
PCB 153+ 132+105 (ng/g wet wt.)	Mussel	BS S50	† 2.800 4.367	0.847 0.327	6 6	*t*-test	2.02
	Clam	BS S50	† 2.583 * †† 0.100	0.799 0	6 6	Wilcoxon Rank-Sum test	1.78
	All	BS S50	† 1.828 † 1.522	0.470 0.498	18 18	Wilcoxon Rank-Sum test	1.39
PCB 157+200 (ng/g wet wt.)	Mussel	BS S50	† 0.517 † 0.433	0.170 0.133	6 6	*t*-test	0.480
	Fish	BS S50	† 0.125 †† 0.050	0.075 0	6 6	Wilcoxon Rank-Sum test	0.167
	All	BS S50	† 0.231 † 0.178	0.076 0.060	18 18	Wilcoxon Rank-Sum test	0.198

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Table A13 (continued)							
Contaminant	**Organism**	**Treatment**	**Mean Concentration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**LSD d_{min}[1]**
PCB 158 (ng/g wet wt.)	Mussel	BS S50	† 0.475 † 0.500	0.205 0.208	6 6	*t*-test	0.651
	Clam	BS S50	† 0.192 †† 0.050	0.142 0	6 6	Wilcoxon Rank-Sum test	0.316
	Fish	BS S50	† 0.125 †† 0.050	0.075 0	6 6	Wilcoxon Rank-Sum test	0.167
	All	BS S50	† 0.264 † 0.200	0.089 0.083	18 18	Wilcoxon Rank-Sum test	0.248
PCB 163+138 (ng/g wet wt.)	Mussel	BS S50	1.533 1.450	0.178 0.257	6 6	*t*-test	0.696
	Clam	BS S50	† 1.225 † 0.417	0.352 0.119	6 6	*t*-test	0.827
	Fish	BS S50	0.700 † 0.725	0.037 0.205	6 6	Wilcoxon Rank-Sum test	0.464
	All	BS S50	† 1.153 † 0.864	0.149 0.152	18 18	*t*-test	0.433
PCB 170+190 (ng/g wet wt.)	Mussel	BS S50	† 0.142 † 0.400	0.092 0.120	6 6	*t*-test	0.337
	Clam	BS S50	1.350 2.800 *	0.281 0.524	6 6	*t*-test	1.33
	All	BS S50	† 0.514 † 1.083	0.171 0.341	18 18	Wilcoxon Rank-Sum test	0.775
PCB 172+197 (ng/g wet wt.)	Mussel	BS S50	† 0.158 † 0.125	0.108 0.075	6 6	Wilcoxon Rank-Sum test	0.294
	All	BS S50	† 0.086 † 0.075	0.036 0.025	18 18	Wilcoxon Rank-Sum test	0.089
PCB 173 (ng/g wet wt.)	Mussel	BS S50	3.617 4.017	0.279 0.830	6 6	*t*-test	1.95
	All	BS S50	† 1.239 † 1.372	0.417 0.523	18 18	Wilcoxon Rank-Sum test	1.36
PCB 174 (ng/g wet wt.)	Mussel	BS S50	† 0.292 † 0.433	0.242 0.319	6 6	Wilcoxon Rank-Sum test	0.891
	All	BS S50	† 0.131 † 0.178	0.081 0.109	18 18	Wilcoxon Rank-Sum test	0.275
PCB 175 (ng/g wet wt.)	Mussel	BS S50	† 0.425 † 0.342	0.174 0.146	6 6	Wilcoxon Rank-Sum test	0.505
	All	BS S50	† 0.175 , 0.147	0.069 0.057	18 18	Wilcoxon Rank-Sum test	0.182
(Sheet 15 of 18)							

Table A13 (continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 177 (ng/g wet wt.)	Mussel	BS S50	† 0.358 † 0.475	0.148 0.192	6 6	Wilcoxon Rank-Sum test	0.540
	All	BS S50	† 0.153 † 0.192	0.058 0.077	18 18	Wilcoxon Rank-Sum test	0.197
PCB 178 (ng/g wet wt.)	Mussel	BS S50	†† 0.067 † 0.208	0.011 0.158	6 6	Wilcoxon Rank-Sum test	0.354
	Fish	BS S50	† 0.142 † 0.708	0.092 0.658	6 6	Wilcoxon Rank-Sum test	1.48
	All	BS S50	† 0.086 † 0.322	0.030 0.223	18 18	Wilcoxon Rank-Sum test	0.457
PCB 180 (ng/g wet wt.)	Fish	BS S50	† 0.125 †† 0.050	0.075 0	6 6	Wilcoxon Rank-Sum test	0.167
	All	BS S50	† 0.158 †† 0.100	0.027 0.017	18 18	Wilcoxon Rank-Sum test	0.064
PCB 183 (ng/g wet wt.)	Mussel	BS S50	† 0.650 † 0.558	0.192 0.247	6 6	Wilcoxon Rank-Sum test	0.698
	All	BS S50	† 0.250 † 0.219	0.091 0.097	18 18	Wilcoxon Rank-Sum test	0.271
PCB 187+182 (ng/g wet wt.)	Mussel	BS S50	† 0.733 † 0.492	0.227 0.259	6 6	*t*-test	0.768
	Clam	BS S50	†† 0.050 † 0.250	0 0.127	6 6	Wilcoxon Rank-Sum test	0.283
	All	BS S50	† 0.278 † 0.264	0.106 0.100	18 18	Wilcoxon Rank-Sum test	0.296
PCB 189 (ng/g wet wt.)	Mussel	BS S50	† 0.242 † 0.333	0.192 0.221	6 6	Wilcoxon Rank-Sum test	0.652
	All	BS S50	† 0.114 † 0.144	0.064 0.076	18 18	Wilcoxon Rank-Sum test	0.202
PCB 191 (ng/g wet wt.)	Mussel	BS S50	† 0.242 † 0.317	0.192 0.220	6 6	Wilcoxon Rank-Sum test	0.651
	All	BS S50	† 0.114 † 0.139	0.064 0.075	18 18	Wilcoxon Rank-Sum test	0.201
PCB 193 (ng/g wet wt.)	Mussel	BS S50	† 0.208 † 0.242	0.158 0.192	6 6	Wilcoxon Rank-Sum test	0.554
	All	BS S50	† 0.103 † 0.114	0.053 0.064	18 18	Wilcoxon Rank-Sum test	0.168

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Table A13 (continued)							
Contaminant	Organ-ism	Treat-ment	Mean Concen-tration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 198 (ng/g wet wt.)	Mussel	BS S50	† 0.142 †† 0.050	0.092 0	6 6	Wilcoxon Rank-Sum test	0.204
	Fish	BS S50	†† 0.050 † 0.725	0 0.675	6 6	Wilcoxon Rank-Sum test	1.50
	All	BS S50	† 0.081 † 0.275	0.031 0.225	18 18	Wilcoxon Rank-Sum test	0.462
PCB 199 (ng/g wet wt.)	Mussel	BS S50	†† 0.050 † 0.208	0 0.158	6 6	Wilcoxon Rank-Sum test	0.353
	All	BS S50	†† 0.050 † 0.103	0 0.053	18 18	Wilcoxon Rank-Sum test	0.107
PCB 201 (ng/g wet wt.)	Mussel	BS S50	† 0.142 † 0.142	0.092 0.092	6 6	Wilcoxon Rank-Sum test	0.289
	All	BS S50	† 0.081 † 0.081	0.031 0.031	18 18	Wilcoxon Rank-Sum test	0.088
PCB 202+171 (ng/g wet wt.)	Mussel	BS S50	† 0.408 † 0.333	0.188 0.181	6 6	Wilcoxon Rank-Sum test	0.581
	Clam	BS S50	† 1.000 † 0.208	0.321 0.158	6 6	*t*-test	0.798
	Fish	BS S50	† 0.142 †† 0.050	0.092 0	6 6	Wilcoxon Rank-Sum test	0.204
	All	BS S50	† 0.517 † 0.197	0.148 0.080	18 18	Wilcoxon Rank-Sum test	0.343
PCB 203+196 (ng/g wet wt.)	Mussel	BS S50	† 0.158 † 0.208	0.108 0.158	6 6	Wilcoxon Rank-Sum test	0.428
	All	BS S50	† 0.086 † 0.103	0.036 0.053	18 18	Wilcoxon Rank-Sum test	0.130
PCB 207 (ng/g wet wt.)	Mussel	BS S50	† 0.225 † 0.450	0.175 0.352	6 6	Wilcoxon Rank-Sum test	0.877
	All	BS S50	† 0.108 † 0.183	0.058 0.119	18 18	Wilcoxon Rank-Sum test	0.270

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Table A13 (Concluded)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
Lipid (percent wet wt.)	Mussel	BS	2.295	0.111	6	*t*-test	0.335
		S50	2.109	0.101	6		
	Clam	BS	1.467	0.212	6	*t*-test (log-transformed data)	0.534
		S50	1.216	0.111	6		
	Fish	BS	1.064	0.069	6	*t*-test	0.208
		S50	1.119	0.063	6		
	All	BS	1.609	0.147	18	Wilcoxon Rank-Sum test	0.385
		S50	1.481	0.120	18		

Table A14.
Oakland Hot Sediment: Descriptive Statistics and Statistical Comparisons of Contaminant Bioaccumulation and Lipid from Bedded Sediment (BS), 50 mg/L Suspended Sediment (S50), and Positive Control (PC) at Day 28, vs. Background (Day 0) Concentrations

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
Acenaphthene (ng/g wet wt.)	Mussel	BS S50 PC Day 0	5.332 8.333 *[2] † 0.635[3] ** 4.757	0.161 0.378 0.366 0.234	6 6 3 3	*t*-tests	1.15
	Clam	BS S50 PC Day 0	53.167 * † 39.600 * †† 0.374 †† 0.761	10.725 10.460 0.128 0.108	6 6 3 3	*t*-tests	41.2
Acenaphthylene (ng/g wet wt.)	Mussel	BS S50 PC Day 0	6.118 * 11.127 * † 0.432 †† 0.167	0.577 0.597 0.282 0.020	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	2.13
	Clam	BS S50 PC Day 0	† 0.452 †† 0.367 †† 0.207 †† 0.125	0.330 0.174 0.071 0.018	6 6 2 3	Nonparametric Dunnett's test (data converted to rankits)	1.03
Anthracene (ng/g wet wt.)	Mussel	BS S50 PC Day 0	13.783 * 42.467 * †† 0.143 † 0.473	1.187 2.027 0.061 0.334	6 6 3 3	Nonparametric Dunnett's test (data converted to rankits)	5.97
	Clam	BS S50 PC Day 0	236.833 * 215.650 * †† 0.228 †† 1.000	24.055 39.486 0.073 0	6 6 3 3	*t*-tests	127
	Fish	BS S50 PC Day 0	† 2.500 †† 1.000 †† 0.253 †† 1.000	1.500 0 – 0	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	5.46
Benz[a]anthracene (ng/g wet wt.)	Mussel	BS S50 PC Day 0	206.667 * 622.500 * † 0.344 † 0.850	27.083 28.477 0.217 0.730	6 6 3 3	Nonparametric Dunnett's test (data converted to rankits)	99.7
	Clam	BS S50 PC Day 0	451.833 * 491.500 * †† 0.196 †† 0.763	27.057 39.799 0.059 0.109	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	132

[1] Minimum significant difference that can be detected by Dunnett's test on untransformed data.
[2] * Indicates a treatment that is significantly greater than Day 0
** indicates a treatment that is
significantly less than Day 0 (two-tailed test, $\alpha/2 = 0.025$).
[3] † Mean includes at least one concentration less than DL and set equal to DL/10;
†† All concentrations less than DL and set equal to DL/10. Comparisons in which all treatments were less than DL are not included in the table.
[4] One outlier (PC) deleted.

(Sheet 1 of 28)

Table A14 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
Benz[a]anthracene (continued)	Fish	BS	† 4.418	3.317	6	Nonparametric *t*-tests (data converted to rankits)	26.3
		S50	† 12.105	10.134	4		
		PC	†† 0.192	--	1		
		Day 0	†† 8.670	0.458	3		
Benzo[a]pyrene (ng/g wet wt.)	Mussel	BS	234.667 *	39.984	6	Nonparametric Dunnett's test (data converted to rankits)	134
		S50	615.333 *	35.738	6		
		PC	† 0.916	0.406	3		
		Day 0	†† 0.082	0.010	3		
	Clam	BS	319.667 *	25.534	6	*t*-tests	116
		S50	378.833 *	33.503	6		
		PC	† 0.834	0.626	2		
		Day 0	†† 0.220	0.030	3		
	Fish	BS	† 2.261	1.928	6	Nonparametric *t*-tests (data converted to rankits)	12.6
		S50	† 5.170	4.544	4		
		PC	†† 0.165	--	1		
		Day 0	†† 2.673	0.100	3		
Benzo[b]fluoranthene (ng/g wet wt.)	Mussel	BS	386.833 *	56.133	6	*t*-tests (log-transformed data)	187
		S50	871.500 *	48.028	6		
		PC	†† 0.104 **	0.035	3		
		Day 0	1.097	0.079	3		
	Clam	BS	425.167 *	34.985	6	*t*-tests	151
		S50	487.667 *	42.157	6		
		PC	†† 0.177	0.050	2		
		Day 0	†† 0.427	0.059	3		
	Fish	BS	† 4.873	4.226	6	Nonparametric *t*-tests (data converted to rankits)	27.8
		S50	† 11.266	10.050	4		
		PC	†† 0.180	--	1		
		Day 0	†† 5.203	0.196	3		
Benzo[k]fluoranthene (ng/g wet wt.)	Mussel	BS	173.000	23.784	6	Nonparametric *t*-tests (data converted to rankits)	85.3
		S50	406.833 *	23.732	6		
		PC	†† 0.103	0.035	3		
		Day 0	† 0.223	0.164	3		
	Clam	BS	204.000 *	18.831	6	*t*-tests	80.0
		S50	230.833 *	22.126	6		
		PC	†† 0.175	0.050	2		
		Day 0	†† 0.243	0.033	3		
	Fish	BS	† 5.578	5.245	6	Nonparametric *t*-tests (data converted to rankits)	21.2
		S50	† 4.695	4.002	4		
		PC	†† 0.178	--	1		
		Day 0	†† 2.963	0.111	3		

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Table A14 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
Benzo-[g,h,i]perylene (ng/g wet wt.)	Mussel	BS S50 PC Day 0	75.317 171.833 * † 0.850 †† 1.837	9.642 10.550 0.351 0.119	6 6 3 3	Nonparametric Dunnett's test (data converted to rankits)	36.3
	Clam	BS S50 PC Day 0	100.117 * 116.933 * † 1.191 †† 0.113	10.587 12.506 0.970 0.016	6 6 2 3	*t*-tests	45.1
	Fish	BS S50 PC Day 0	† 0.673 †† 0.421 3.290 †† 1.380	0.502 0.105 – 0.053	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	1.85
Chrysene (ng/g wet wt.)	Mussel	BS S50 PC Day 0	360.667 924.833 * † 0.436 2.533	39.492 37.142 0.314 0.635	6 6 3 3	Nonparametric Dunnett's test (data converted to rankits)	138
	Clam	BS S50 PC Day 0	629.667 * 696.833 * † 1.665 † 1.022	40.512 54.233 1.436 0.689	6 6 2 3	*t*-tests	186
	Fish	BS S50 PC Day 0	† 4.417 † 7.589 †† 0.173 †† 3.307	3.997 6.838 – 0.174	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	21.5
Dibenz-[a,h]anthracene (ng/g wet wt.)	Mussel	BS S50 PC Day 0	12.228 * 16.708 * †† 0.115 †† 0.056	1.905 3.769 0.039 0.007	6 6 3 3	*t*-tests	10.7
	Clam	BS S50 PC Day 0	24.800 * 26.567 * †† 0.195 †† 0.535	3.156 1.836 0.055 0.074	6 6 2 3	*t*-tests	10.0
Dibenzothiophene (ng/g wet wt.)	Mussel	BS S50 PC Day 0	2.942 * 9.135 * † 0.364 † 0.571	0.212 1.484 0.199 0.394	6 6 3 3	*t*-tests	1.43
	Clam	BS S50 PC Day 0	43.417 * 42.450 * †† 0.219 †† 0.696	5.669 7.596 0.071 0.100	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	26.1

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Table A14 (Continued)							
Contaminant	**Organism**	**Treatment**	**Mean Concentration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**Dunnett d_{min}[1]**
Fluoranthene (ng/g wet wt.)	Mussel	BS	310.667 *	25.289	6	Nonparametric Dunnett's test (data converted to rankits)	118
		S50	1075.167 *	38.953	6		
		PC	† 1.078	0.522	3		
		Day 0	4.253	0.353	3		
	Clam	BS	1785.000 *	112.183	6	*t*-tests	586
		S50	1870.833 *	181.128	6		
		PC	4.145	1.525	2		
		Day 0	9.020	0.367	3		
	Fish	BS	† 12.721	11.494	6	Nonparametric *t*-tests (data converted to rankits)	47.6
		S50	† 12.935	9.845	4		
		PC	†† 0.196	--	1		
		Day 0	†† 3.423	0.180	3		
Fluorene (ng/g wet wt.)	Mussel	BS	4.575	0.066	6	*t*-tests	1.15
		S50	6.770 *	0.368	6		
		PC	† 1.165 **	0.490	3		
		Day 0	4.880	0.308	3		
	Clam	BS	32.283 *	4.131	6	Dunnett's test	19.6
		S50	† 24.912	5.719	6		
		PC	† 4.129	3.761	2		
		Day 0	7.987	0.343	3		
Indeno[1,2,3-cd]pyrene (ng/g wet wt.)	Mussel	BS	51.550 *	7.560	6	Nonparametric *t*-tests (data converted to rankits)	31.0
		S50	136.000 *	9.578	6		
		PC	† 0.701	0.590	3		
		Day 0	1.257	0.128	3		
	Clam	BS	71.950 *	7.334	6	*t*-tests	33.8
		S50	85.250 *	9.828	6		
		PC	† 2.349	2.142	2		
		Day 0	†† 0.319	0.044	3		
	Fish	BS	† 1.064	0.582	6	Nonparametric *t*-tests (data converted to rankits)	2.24
		S50	†† 1.184	0.295	4		
		PC	2.750	--	1		
		Day 0	†† 3.880	0.144	3		
Naphthalene (ng/g wet wt.)	Mussel	BS	58.533	1.716	6	*t*-tests	9.56
		S50	57.933	3.096	6		
		PC	13.533 **	1.099	3		
		Day 0	67.667	2.674	3		
	Clam	BS	65.917	2.078	6	*t*-tests	19.3
		S50	53.567	6.127	6		
		PC	17.200	2.400	2		
		Day 0	47.367	5.978	3		
	Fish	BS	53.350 *	3.099	6	*t*-tests	28.8
		S50	80.850 *	11.103	4		
		PC	28.400	--	1		
		Day 0	22.000	4.126	3		

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Table A14 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
Phenanthrene (ng/g wet wt.)	Mussel	BS	49.450 *	2.102	6	*t*-tests	23.2
		S50	137.667 *	8.188	6		
		PC	16.083	7.634	3		
		Day 0	29.833	1.590	3		
	Clam	BS	634.167 *	74.371	6	*t*-tests	369
		S50	610.167 *	111.161	6		
		PC	35.855	30.645	2		
		Day 0	24.367	2.256	3		
	Fish	BS	26.917 *	3.650	6	Dunnett's test (log-transformed data)	18.3
		S50	36.650 *	5.448	4		
		PC	6.810 *	–	1		
		Day 0	†† 2.790	0.167	3		
Pyrene (ng/g wet wt.)	Mussel	BS	294.167	21.313	6	Nonparametric Dunnett's test (data converted to rankits)	275
		S50	1415.000 *	106.325	6		
		PC	† 1.167	0.611	3		
		Day 0	2.897	0.329	3		
	Clam	BS	1750.000 *	101.915	6	*t*-tests	604
		S50	1958.333 *	194.258	6		
		PC	† 2.120	1.900	2		
		Day 0	2.130	0.736	3		
	Fish	BS	† 11.783	10.783	6	Nonparametric *t*-tests (data converted to rankits)	41.9
		S50	† 7.325	6.325	4		
		PC	†† 0.166	–	1		
		Day 0	†† 1.000	0	3		
Cd (µg/g dry wt.)	Mussel	BS	6.527 *	0.399	6	Nonparametric Dunnett's test (data converted to rankits)	11.8
		S50	6.752 *	0.347	6		
		PC	32.300 *	10.292	3		
		Day 0	3.610	0.108	3		
	Clam	BS	0.310	0.041	6	*t*-tests (log-transformed data)	0.704
		S50	0.279	0.034	6		
		PC	1.413	0.968	2		
		Day 0	0.248	0.037	3		
	Fish	BS	0.480	0.018	6	Dunnett's test	0.108
		S50	0.274 **	0.022	6		
		PC	0.723	–	1		
		Day 0	0.583	0.048	3		

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Table A14 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min} [1]
Cr (μg/g dry wt.)	Mussel	BS	4.017 *	0.605	6	*t*-tests	1.73
		S50	3.600 *	0.291	6		
		PC	1.400	0.265	3		
		Day 0	0.557	0.003	3		
	Clam	BS	5.517 *	0.733	6	Dunnett's test (log-transformed data)	2.67
		S50	3.817 *	0.606	6		
		PC	2.650 *	0.750	2		
		Day 0	0.950	0.090	3		
	Fish	BS	0.990 *	0.059	6	*t*-tests	0.485
		S50	0.778	0.142	6		
		PC	0.740	--	1		
		Day 0	0.477	0.101	3		
Hg (μg/g dry wt.)	Mussel	BS	0.285 *	0.005	6	*t*-tests	0.044
		S50	0.309	0.016	6		
		PC	0.278	0.010	3		
		Day 0	0.254	0.007	3		
	Clam	BS	0.165 *	0.012	6	*t*-tests	0.042
		S50	0.142	0.010	6		
		PC	0.141 *	0.002	2		
		Day 0	0.115	0.002	3		
	Fish	BS	0.270 *	0.046	6	*t*-tests	0.222
		S50	0.270	0.057	6		
		PC	0.232 *	--	1		
		Day 0	0.090	0.004	3		
TBT (ng/g wet wt.)	Mussel	BS	77.083 *	16.057	6	*t*-tests (log-transformed data)	46.4
		S50	40.480 *	2.843	5		
		PC	87.700 *	10.908	3		
		Day 0	1.067	0.120	3		
	Clam	BS	19.440 *	2.573	5	Dunnett's test	12.4
		S50	23.567 *	2.723	6		
		PC	15.500	--	1		
		Day 0	†† 0.290	0.010	2		
	Fish	BS	9.800 *	1.079	3	*t*-test (log-transformed data)	4.11
		PC	†† 1.340	--	1		
		Day 0	†† 0.243	0.084	3		
DBT (ng/g wet wt.)	Mussel	BS	15.617 *	1.931	6	Dunnett's test (log-transformed data)	7.00
		S50	6.860 *	0.985	5		
		PC	19.167 *	3.292	3		
		Day 0	† 0.767	0.133	3		
	Clam	BS	3.120 *	0.483	5	Dunnett's test	1.95
		S50	4.417 *	0.371	6		
		PC	†† 0.230	--	1		
		Day 0	†† 0.275	0.015	2		

(Sheet 6 of 28)

Table A14 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
MBT (ng/g wet wt.)	Mussel	BS	† 0.635	0.155	6	Nonparametric t-tests (data converted to rankits)	0.508
		S50	†† 0.326	0.015	5		
		PC	† 0.550	0.225	3		
		Day 0	†† 0.330	0.006	3		
Aroclor 1254 (ng/g wet wt.)	Mussel	BS	70.583 *	9.059	6	*t*-tests	30.5
		S50	95.500 *	6.360	6		
		PC	†† 2.000	0	2		
		Day 0	†† 2.000	0	3		
PCB 8+5 (ng/g wet wt.)	Mussel	BS	2.717	0.508	6	*t*-tests (log-transformed data)	6.72
		S50	† 0.583	0.383	6		
		PC	† 5.767	5.567	3		
		Day 0	† 3.000	1.430	3		
	Clam	BS	4.367 *	0.784	6	*t*-tests (log-transformed data)	7.95
		S50	† 1.717	0.722	6		
		PC	† 10.600	10.400	2		
		Day 0	†† 0.200	0	3		
	Fish	BS	† 148.367	93.022	6	Nonparametric *t*-tests (data converted to rankits)	339
		S50	† 5.875	5.675	4		
		PC	†† 0.200	–	1		
		Day 0	†† 0.200	0	3		
PCB 17 (ng/g wet wt.)	Mussel	BS	1.200	0.113	6	Nonparametric *t*-tests (data converted to rankits)	1.63
		S50	† 0.892	0.188	6		
		PC	† 2.383	1.266	3		
		Day 0	† 0.917	0.457	3		
	Clam	BS	6.483	0.990	6	*t*-tests (log-transformed data)	5.84
		S50	5.850	1.761	6		
		PC	† 0.725	0.675	2		
		Day 0	2.033	1.384	3		
	Fish	BS	† 1.392	1.072	6	*t*-tests (log-transformed data)	3.93
		S50	0.700	0.135	4		
		PC	8.300	–	1		
		Day 0	† 0.493	0.217	3		
PCB 18 (ng/g wet wt.)	Mussel	BS	1.667 *	0.088	6	Nonparametric Dunnett's test (data converted to rankits)	3.49
		S50	† 0.808	0.177	6		
		PC	7.367 *	3.037	3		
		Day 0	† 0.550	0.250	3		
	Clam	BS	† 0.517	0.157	6	*t*-tests (log-transformed data)	2.10
		S50	† 0.333	0.186	6		
		PC	4.700	2.800	2		
		Day 0	†† 0.050	0	3		
	Fish	BS	† 0.692	0.134	6	Dunnett's test	0.954
		S50	1.000	0.308	4		
		PC	9.100 *	–	1		
		Day 0	† 0.300	0.250	3		

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Table A14 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
PCB 19 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.375 † 0.158 4.100 † 0.417	0.148 0.108 1.155 0.192	6 6 3 3	*t*-tests (log-transformed data)	1.41
	Clam	BS S50 PC Day 0	† 1.558 † 2.175 6.000 1.933	0.706 0.680 1.400 0.584	6 6 2 3	*t*-tests (log-transformed data)	2.96
	Fish	BS S50 PC Day 0	† 0.808 † 0.313 14.000 0.800	0.758 0.263 -- 0.115	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	2.83
PCB 22 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	4.050 * 4.350 * † 6.817 † 0.333	0.274 0.430 3.401 0.283	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	4.08
	Clam	BS S50 PC Day 0	8.850 * 7.317 * † 7.225 † 1.850	0.988 0.804 7.175 1.580	6 6 2 3	*t*-tests	6.49
	Fish	BS S50 PC Day 0	† 1.242 † 1.963 7.500 * † 0.133	0.356 0.699 -- 0.083	6 4 1 3	Nonparametric Dunnett's test (data converted to rankits)	2.07
PCB 25 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	6.383 * 5.250 * 7.967 † 0.267	0.755 0.678 3.641 0.217	6 6 3 3	*t*-tests	4.87
	Clam	BS S50 PC Day 0	3.200 * † 1.625 † 7.375 † 0.517	0.306 0.353 7.325 0.249	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	5.37
	Fish	BS S50 PC Day 0	† 0.800 † 2.025 †† 0.050 †† 0.050	0.475 1.226 -- 0	6 4 1 3	*t*-tests	3.31

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Table A14 (Continued)							
Contaminant	**Organism**	**Treatment**	**Mean Concentration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**Dunnett d_{min}[1]**
PCB 26 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 1.917 †† 0.200 5.533 * †† 0.200	0.562 0 1.105 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.90
	Clam	BS S50 PC Day 0	† 0.933 † 0.933 † 17.625 † 9.233	0.633 0.633 17.575 5.480	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	14.4
	Fish	BS S50 PC Day 0	† 1.217 † 3.500 11.800 †† 0.300	0.580 1.083 – 0	6 4 1 3	*t*-tests	3.27
PCB 29 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	†† 0.050 † 0.175 †† 0.050 † 1.183	0 0.125 0 0.567	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.718
	Clam	BS S50 PC Day 0	†† 0.050 † 0.442 † 0.425 † 0.233	0 0.180 0.375 0.183	6 6 2 3	*t*-tests	0.605
	Fish	BS S50 PC Day 0	† 0.725 † 0.163 †† 0.050 † 0.233	0.675 0.113 – 0.183	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	2.49
PCB 31+28 (ng/g wet wt.)	Mussel	PC Day 0	6.133 †† 0.200	2.360 0	3 3	*t*-test	6.56
	Clam	BS S50 PC Day 0	9.633 5.667 17.100 † 2.267	1.084 1.058 10.500 0.987	6 6 2 3	*t*-tests (log-transformed data)	8.63
	Fish	BS S50 PC Day 0	† 4.683 * 7.250 * 10.900 †† 0.300	0.939 0.459 – 0	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	3.58

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Table A14 (Continued)							
Contaminant	**Organism**	**Treatment**	**Mean Concentration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**Dunnett d_{min}[1]**
PCB 32+16 (ng/g wet wt.)	Mussel	BS	3.317 *	0.244	6	*t*-tests	1.84
		S50	† 2.150 *	0.407	6		
		PC	6.133	1.225	3		
		Day 0	†† 0.200	0	3		
	Clam	BS	† 1.750	0.649	6	Nonparametric *t*-tests (data converted to rankits)	8.85
		S50	† 1.300	0.635	6		
		PC	16.450	11.950	2		
		Day 0	†† 0.300	0	3		
	Fish	BS	† 3.100	2.800	6	Nonparametric *t*-tests (data converted to rankits)	10.3
		S50	† 1.025	0.725	4		
		PC	17.500	--	1		
		Day 0	†† 0.300	0	3		
PCB 33 and PCB 33+53 (ng/g wet wt.)	Mussel	BS	†† 0.200	0	6	Nonparametric *t*-tests (data converted to rankits)	1.23
		S50	†† 0.200	0	6		
		PC	3.033	0.974	3		
		Day 0	†† 0.200	--	1		
	Clam	BS	†† 0.200	0	5	Nonparametric *t*-tests (data converted to rankits)	1.78
		S50	†† 0.200	0	5		
		PC	8.050	1.850	2		
		Day 0	3.400	0.600	2		
	Fish	BS	5.450 **	1.822	6	Dunnett's test	9.48
		S50	9.675 **	2.374	4		
		PC	†† 0.050 **	--	1		
		Day 0	27.900	2.454	3		
PCB 40 (ng/g wet wt.)	Mussel	BS	2.717 *	0.204	6	Nonparametric *t*-tests (data converted to rankits)	9.92
		S50	† 1.317 *	0.281	6		
		PC	13.333	8.707	3		
		Day 0	†† 0.100	0	3		
	Clam	BS	† 0.775 *	0.150	6	Nonparametric *t*-tests (data converted to rankits)	12.6
		S50	† 0.192	0.142	6		
		PC	† 17.825	17.775	2		
		Day 0	†† 0.050	0	3		
	Fish	BS	† 0.675	0.625	6	Nonparametric *t*-tests (data converted to rankits)	2.31
		S50	† 0.213	0.163	4		
		PC	10.300	--	1		
		Day 0	†† 0.050	0	3		

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Table A14 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
PCB 42+37 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 1.283 † 0.817 15.900 † 0.933	0.263 0.337 3.487 0.426	6 6 3 3	*t*-tests (log-transformed data)	4.13
	Clam	BS S50 PC Day 0	0.967 † 0.400 27.550 * †† 0.083	0.096 0.227 12.350 0.017	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	8.80
	Fish	BS S50 PC Day 0	† 0.500 † 0.375 17.600 † 1.000	0.400 0.275 -- 0.451	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	1.75
PCB 44 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	3.000 * 3.167 * † 1.417 1.133	0.482 0.274 0.794 0.233	6 6 3 3	Dunnett's test	1.69
	Clam	BS S50 PC Day 0	† 2.433 * † 1.300 † 1.025 †† 0.200	0.540 0.573 0.975 0	6 6 2 3	*t*-tests	2.27
	Fish	BS S50 PC Day 0	† 0.600 †† 0.200 2.500 † 1.833	0.400 0 -- 0.821	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	1.98
PCB 45 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	2.583 * † 2.117 2.967 * †† 0.200	0.070 0.384 0.384 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.08
	Clam	BS S50 PC Day 0	4.783 3.933 † 0.875 3.500	0.778 0.300 0.825 0.208	6 6 2 3	*t*-tests	2.38
	Fish	BS S50 PC Day 0	† 1.200 3.350 * 4.400 †† 0.200	0.448 0.210 -- 0	6 4 1 3	*t*-tests	1.70

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Table A14 (Continued)							
Contaminant	**Organism**	**Treatment**	**Mean Concentration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**Dunnett d_{min}[1]**
PCB 46 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	†† 0.050 † 0.208 † 2.083 † 0.417	0 0.158 1.230 0.192	6 6 3 3	*t*-tests (log-transformed data)	1.47
	Clam	BS S50 PC Day 0	†† 0.050 † 4.375 † 3.825 †† 0.050	0 2.520 3.775 0	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	7.44
PCB 48+47 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 1.683 † 0.467 7.467 * †† 0.050	0.646 0.265 1.668 0	6 6 3 3	*t*-tests (log-transformed data)	2.59
PCB 49 and PCB 49+43 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	3.433 * 3.850 * † 3.383 †† 0.100	0.391 0.186 1.673 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	2.19
	Clam	BS S50 PC Day 0	3.183 * 2.967 * 16.300 1.400	0.196 0.117 13.400 0.100	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	9.54
	Fish	BS S50 PC Day 0	2.650 * 5.325 * †† 0.050 † 0.350	0.449 0.887 -- 0.161	6 4 1 3	*t*-tests	2.63
PCB 56+60 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	1.867 * 2.700 * 14.100 * †† 0.050	0.265 0.252 5.680 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	6.51
	Clam	BS S50 PC Day 0	2.000 * † 1.242 * 23.750 †† 0.050	0.421 0.295 9.050 0	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	6.59
	Fish	BS S50 PC Day 0	† 0.325 † 0.238 †† 0.200 †† 0.050	0.275 0.188 -- 0	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	1.09

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Table A14 (Continued)							
Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
PCB 63 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	5.033 * 2.450 † 4.117 † 0.267	0.301 0.226 2.245 0.217	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	2.73
	Clam	BS S50 PC Day 0	2.250 1.550 † 4.125 3.333	0.337 0.161 4.075 1.342	6 6 2 3	*t*-tests	3.49
	Fish	BS S50 PC Day 0	† 3.800 * † 3.750 6.700 †† 0.300	0.861 2.109 – 0	6 4 1 3	*t*-tests	5.78
PCB 64+41+71 (ng/g wet wt.)	Mussel	PC Day 0	† 1.333 †† 0.200	1.133 0	3 3	Nonparametric *t*-test (data converted to rankits)	3.15
	Clam	S50 PC Day 0	†† 0.300 † 10.350 †† 0.300	0 10.150 0	6 2 3	Nonparametric *t*-tests (data converted to rankits)	10.0
	Fish	BS S50 PC Day 0	† 1.000 ** † 2.925 ** 4.700 30.533	0.700 0.909 – 2.293	6 4 1 3	*t*-tests	4.98
PCB 70+76 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 2.917 * 4.883 * † 1.867 †† 0.200	0.570 0.285 0.902 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.91
	Clam	BS S50 PC Day 0	4.017 * 3.367 * †† 0.200 †† 0.200	0.320 0.223 0 0	6 6 2 3	*t*-tests	1.07
	Fish	BS S50 PC Day 0	† 0.567 †† 0.200 4.600 †† 0.200	0.367 0 – 0	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	1.34
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Table A14 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	*N*	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
PCB 74 (ng/g wet wt.)	Mussel	BS	1.433 *	0.117	6	Nonparametric *t*-tests (data converted to rankits)	1.70
		S50	1.500 *	0.097	6		
		PC	† 1.500	1.450	3		
		Day 0	† 0.233	0.183	3		
	Clam	BS	0.917 *	0.054	6	Nonparametric *t*-tests (data converted to rankits)	7.80
		S50	0.783 *	0.091	6		
		PC	† 11.025	10.975	2		
		Day 0	†† 0.050	0	3		
	Fish	BS	† 0.625 *	0.125	6	Dunnett's test	0.563
		S50	0.975 *	0.144	4		
		PC	9.600 *	–	1		
		Day 0	†† 0.050	0	3		
PCB 82 (ng/g wet wt.)	Mussel	BS	† 0.925 *	0.179	6	Nonparametric *t*-tests (data converted to rankits)	2.28
		S50	1.367 *	0.092	6		
		PC	7.400 *	1.955	3		
		Day 0	†† 0.050	0	3		
	Clam	BS	21.800	6.345	6	*t*-tests	28.8
		S50	18.100	3.417	6		
		PC	57.450	29.450	2		
		Day 0	22.733	0.694	3		
	Fish	BS	† 0.542	0.492	6	Nonparametric *t*-tests (data converted to rankits)	1.87
		S50	† 0.400	0.226	4		
		PC	12.100	–	1		
		Day 0	† 0.133	0.083	3		
PCB 83 (ng/g wet wt.)	Mussel	BS	† 0.908 *	0.206	6	*t*-tests	0.875
		S50	1.517 *	0.289	6		
		Day 0	†† 0.050	0	3		
	Clam	BS	† 0.658	0.140	6	Dunnett's test	0.663
		S50	† 0.600	0.219	6		
		Day 0	0.700	0.153	3		
	Fish	BS	† 0.642	0.131	6	Dunnett's test	0.588
		S50	1.100	0.208	4		
		Day 0	0.833	0.145	3		

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Table A14 (Continued)							
Contaminant	Organ-ism	Treat-ment	Mean Concen-tration	Standard Error	N	Test Used for Statis-tical Comparisons	Dunnett d_{min}[1]
PCB 84 and PCB 92+84 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	2.567 2.800 * † 2.883 † 0.617	0.486 0.369 2.238 0.332	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	3.00
	Clam	BS S50 PC Day 0	† 0.608 † 0.508 9.500 † 0.833	0.287 0.227 5.600 0.783	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	4.22
	Fish	BS S50 PC Day 0	† 0.858 † 0.988 †† 0.050 1.567	0.196 0.403 -- 0.120	6 4 1 3	Dunnett's test	1.19
PCB 85 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	4.567 * 6.100 * † 63.550 †† 0.200	0.425 0.375 52.906 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	60.1
	Clam	BS S50 PC Day 0	† 2.567 * 2.633 * 21.400 †† 0.050	0.551 0.169 8.600 0	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	6.31
	Fish	BS S50 PC Day 0	6.800 * 7.900 * 4.800 4.533	0.208 1.163 -- 0.120	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	2.79
PCB 87 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	2.000 * 2.917 * 2.467 * †† 0.050	0.261 0.158 1.020 0	6 6 3 3	*t*-tests (log-transformed data)	1.39
	Clam	BS S50 PC Day 0	† 1.242 1.383 † 5.225 † 0.267	0.272 0.135 5.175 0.217	6 6 2 3	*t*-tests (log-transformed data)	3.78
	Fish	BS S50 PC Day 0	† 0.892 * 1.500 * 4.900 †† 0.050	0.193 0.212 -- 0	6 4 1 3	*t*-tests	0.857

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Table A14 (Continued)							
Contaminant	**Organism**	**Treatment**	**Mean Concentration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**Dunnett d_{min}**[1]
PCB 91 (ng/g wet wt.)	Mussel	BS	2.183 *	0.218	6	*t*-tests	0.970
		S50	2.383 *	0.298	6		
		PC	1.567 *	0.120	3		
		Day 0	† 0.233	0.183	3		
	Clam	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	3.47
		S50	0.250	0.142	6		
		PC	6.150	4.850	2		
		Day 0	†† 0.050	0	3		
	Fish	BS	† 0.158	0.108	6	Dunnett's test	0.660
		S50	† 0.488	0.159	4		
		PC	3.800 *	–	1		
		Day 0	† 0.517	0.235	3		
PCB 95+66 (ng/g wet wt.)	Mussel	PC	† 5.800	2.859	3	*t*-test	7.94
		Day 0	†† 0.500	0	3		
	Clam	PC	27.150	17.850	2	*t*-test	–
		Day 0	†† 0.500	0	3		
	Fish	BS	† 4.033 **	1.130	6	Dunnett's test	6.35
		S50	11.650 **	1.735	4		
		PC	14.800 **	–	1		
		Day 0	32.500	1.664	3		
PCB 97 (ng/g wet wt.)	Mussel	BS	1.283 *	0.182	6	Nonparametric Dunnett's test (data converted to rankits)	1.93
		S50	1.417 *	0.070	6		
		PC	6.433 *	1.633	3		
		Day 0	† 0.233	0.183	3		
	Clam	PC	† 1.125	1.075	2	*t*-test	–
		Day 0	†† 0.050	0	3		
	Fish	BS	† 0.283	0.161	6	*t*-tests (log-transformed data)	2.60
		S50	† 0.988	0.399	4		
		PC	9.900	–	1		
		Day 0	† 2.283	1.449	3		
PCB 99 (ng/g wet wt.)	Mussel	BS	1.983 *	0.281	6	Nonparametric *t*-tests (data converted to rankits)	2.21
		S50	2.550 *	0.134	6		
		PC	† 2.617	1.806	3		
		Day 0	† 0.300	0.250	3		
	Clam	BS	1.400 *	0.148	6	*t*-tests	0.549
		S50	1.250 *	0.134	6		
		PC	†† 0.050	0	2		
		Day 0	†† 0.050	0	3		
	Fish	BS	† 0.775 *	0.161	6	Nonparametric *t*-tests (data converted to rankits)	0.660
		S50	1.525 *	0.132	4		
		PC	3.100	–	1		
		Day 0	†† 0.050	0	3		

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Table A14 (Continued)							
Contaminant	**Organism**	**Treatment**	**Mean Concentration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**Dunnett d_{min}[1]**
PCB 100 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	†† 0.050 †† 0.050 4.767 † 0.200	0 0 1.501 0.150	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.71
	Clam	BS S50 PC Day 0	0.900 * † 0.558 27.850 †† 0.050	0.093 0.241 23.850 0	6 6 2 3	*t*-tests (log-transformed data)	17.0
	Fish	BS S50 PC Day 0	† 0.283 †† 0.050 8.700 †† 0.050	0.161 0 – 0	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	0.587
PCB 101 and PCB 101+89 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	5.617 * 6.683 * 2.567 †† 0.050	0.694 0.350 1.048 0	6 6 3 3	*t*-tests	2.30
	Clam	BS S50 PC Day 0	4.967 * 4.667 * 7.200 †† 0.050	0.510 0.332 5.300 0	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	4.12
	Fish	BS S50 PC Day 0	2.450 * 3.575 * 7.700 †† 0.050	0.362 0.384 – 0	6 4 1 3	*t*-tests	1.59
PCB 107 (ng/g wet wt.)	Mussel	BS S50 Day 0	† 0.542 † 0.433 † 0.583	0.107 0.122 0.280	6 6 3	Nonparametric Dunnett's test (data converted to rankits)	0.506
	Clam	BS S50 Day 0	† 0.142 †† 0.050 †† 0.050	0.092 0 0	6 6 3	Nonparametric *t*-tests (data converted to rankits)	0.226
	Fish	BS S50 Day 0	† 0.283 0.425 † 0.283	0.148 0.217 0.130	6 4 3	Nonparametric *t*-tests (data converted to rankits)	0.629

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Table A14 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
PCB 110 and PCB 110+77 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	7.917 * 11.400 * † 1.033 †† 0.050	1.057 0.585 0.983 0	6 6 3 3	*t*-tests	3.26
	Clam	BS S50 PC Day 0	7.517 * 7.350 * †† 0.050 †† 0.050	0.720 0.578 0 0	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	2.54
	Fish	BS S50 PC Day 0	2.750 * 4.650 * †† 0.050 †† 0.050	0.422 0.380 – 0	6 4 1 3	*t*-tests	1.77
PCB 118 and PCB 118+149 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	4.600 * 6.333 * 0.800 †† 0.050	0.553 0.356 0.100 0	6 6 3 3	*t*-tests	1.67
	Clam	BS S50 PC Day 0	3.183 * 3.267 * 4.900 †† 0.050	0.345 0.318 4.200 0	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	3.25
	Fish	BS S50 PC Day 0	1.883 * 2.950 * 2.100 †† 0.050	0.241 0.150 – 0	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	0.945
PCB 128 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	1.200 * 1.067 * † 2.783 † 0.200	0.097 0.042 1.417 0.150	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.64
	Clam	BS S50 PC Day 0	† 0.692 * † 0.433 † 2.025 †† 0.050	0.146 0.125 1.975 0	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	1.50
	Fish	BS S50 PC Day 0	†† 0.050 †† 0.050 †† 0.050 † 0.200	0 0 – 0.150	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	0.244

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Table A14 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
PCB 131 (ng/g wet wt.)	Mussel	BS	† 0.342	0.136	6	*t*-tests (log-transformed data)	0.670
		S50	1.100 *	0.235	6		
		Day 0	†† 0.050	0	3		
	Clam	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	0.185
		S50	† 0.125	0.075	6		
		Day 0	†† 0.050	0	3		
	Fish	BS	†† 0.050 **	0	6	Nonparametric *t*-tests (data converted to rankits)	0.045
		S50	†† 0.050 **	0	4		
		Day 0	1.367	0.033	3		
PCB 134+114 (ng/g wet wt.)	Mussel	BS	3.867 *	0.739	6	Dunnett's test	3.09
		S50	7.567 *	1.006	6		
		Day 0	† 0.267	0.217	3		
	Clam	BS	2.150 *	0.423	6	*t*-tests	1.41
		S50	1.783 *	0.382	6		
		Day 0	†† 0.050	0	3		
	Fish	BS	0.917	0.070	6	Nonparametric Dunnett's test (data converted to rankits)	1.87
		S50	2.700 *	0.970	4		
		Day 0	1.033	0.186	3		
PCB 135+144 (ng/g wet wt.)	Mussel	BS	† 0.550	0.350	6	Nonparametric *t*-tests (data converted to rankits)	1.45
		S50	† 0.867	0.422	6		
		PC	† 0.717	0.344	3		
		Day 0	†† 0.200	0	3		
	Clam	BS	†† 0.200	0	3	Nonparametric *t*-tests (data converted to rankits)	2.27
		S50	†† 0.200	0	3		
		PC	1.400	0.700	2		
		Day 0	† 1.933	0.874	3		
	Fish	BS	† 1.417 **	0.586	6	*t*-tests	4.47
		S50	5.300 **	1.529	4		
		PC	†† 0.050 **	--	1		
		Day 0	25.667	1.065	3		
PCB 136 (ng/g wet wt.)	Mussel	BS	4.850	0.966	6	Nonparametric *t*-tests (data converted to rankits)	6.84
		S50	† 5.175	1.144	6		
		PC	† 10.050	5.010	3		
		Day 0	2.067	0.260	3		
	Clam	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	18.4
		S50	†† 0.050	0	6		
		PC	47.300	25.900	2		
		Day 0	†† 0.050	0	3		
	Fish	BS	† 0.242	0.192	6	Nonparametric *t*-tests (data converted to rankits)	0.698
		S50	†† 0.050	0	4		
		PC	†† 0.050	--	1		
		Day 0	†† 0.050	0	3		

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Table A14 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min} [1]
PCB 137+176 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	2.000 * 2.317 * †† 0.050 †† 0.050	0.100 0.125 0 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.406
	Clam	BS S50 PC Day 0	†† 0.050 †† 0.050 † 1.725 †† 0.050	0 0 1.675 0	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	1.19
PCB 141 (ng/g wet wt.)	Clam	BS S50 PC Day 0	3.233 * 2.267 † 1.400 † 0.900	0.361 0.133 1.200 0.700	6 6 2 3	*t*-tests	1.61
	Fish	BS S50 PC Day 0	† 2.683 4.325 † 0.200 2.767	0.511 0.382 -- 0.433	6 4 1 3	Nonparametric Dunnett's test (data converted to rankits)	2.18
PCB 146 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	†† 0.400 † 2.583 2.633 * †† 0.400	0 0.979 0.536 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	2.56
	Clam	BS S50 PC Day 0	2.983 2.533 †† 0.050 † 2.167	0.101 0.178 0 0.984	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	1.34
	Fish	BS S50 PC Day 0	† 2.950 † 3.500 †† 0.050 † 1.933	0.567 1.162 -- 0.956	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	3.72
PCB 149 (ng/g wet wt.)	Mussel	BS S50 Day 0	6.117 * 5.617 * †† 0.050	0.858 0.506 0	6 6 3	*t*-tests	2.46
	Clam	BS S50 Day 0	3.283 * 2.600 * †† 0.050	0.440 0.171 0	6 6 3	*t*-tests	1.16
	Fish	BS S50 Day 0	† 1.592 * 1.825 †† 0.050	0.320 0.132 0	6 4 3	Nonparametric *t*-tests (data converted to rankits)	0.990

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Table A14 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
PCB 151 (ng/g wet wt.)	Mussel	BS	1.583 *	0.215	6	Nonparametric *t*-tests (data converted to rankits)	1.38
		S50	1.233 *	0.088	6		
		PC	† 2.117	1.099	3		
		Day 0	†† 0.050	0	3		
	Clam	BS	1.167 *	0.163	6	*t*-tests	0.521
		S50	0.800 *	0.097	6		
		PC	†† 0.050	0	2		
		Day 0	†† 0.050	0	3		
	Fish	BS	0.633 *	0.350	6	*t*-tests	0.469
		S50	0.056	0.184	4		
		PC	†† 0.050	–	1		
		Day 0	†† 0.050	0	3		
PCB 153+132+105 (ng/g wet wt.)	Mussel	BS	15.617 *	2.016	6	Nonparametric *t*-tests (data converted to rankits)	61.4
		S50	12.217 *	0.914	6		
		PC	† 55.433	53.839	3		
		Day 0	†† 0.300	0	3		
	Clam	BS	9.867	1.948	6	*t*-tests (log-transformed data)	8.50
		S50	8.417	1.775	6		
		PC	† 6.350	6.150	2		
		Day 0	† 0.833	0.633	3		
	Fish	BS	3.867 *	0.228	6	*t*-tests (log-transformed data)	2.39
		S50	5.600 *	0.974	4		
		PC	32.200	–	1		
		Day 0	†† 0.200	0	3		
PCB 157+200 (ng/g wet wt.)	Mussel	BS	† 0.558	0.116	6	*t*-tests (log-transformed data)	1.98
		S50	0.750	0.173	6		
		PC	3.967	1.676	3		
		Day 0	† 0.200	0.150	3		
	Clam	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	1.18
		S50	† 0.142	0.092	6		
		PC	† 1.675	1.625	2		
		Day 0	†† 0.050	0	3		
	Fish	BS	† 0.250 **	0.132	6	*t*-tests	0.687
		S50	† 0.400 **	0.211	4		
		PC	†† 0.050 **	–	1		
		Day 0	2.067	0.033	3		

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Table A14 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
PCB 158 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	1.500 * 2.333 * 3.767 †† 0.050	0.177 0.481 1.468 0	6 6 3 3	*t*-tests (log-transformed data)	2.11
	Clam	BS S50 PC Day 0	† 0.500 †† 0.100 † 1.125 †† 0.067	0.254 0 1.075 0.017	6 6 2 3	*t*-tests	1.04
	Fish	BS S50 PC Day 0	† 0.142 ** † 0.313 ** 12.100 3.633	0.092 0.263 -- 0.219	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	0.777
PCB 163+138 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	8.483 * 9.367 * † 0.767 † 0.267	1.011 0.499 0.717 0.217	6 6 3 3	*t*-tests	2.98
	Clam	BS S50 PC Day 0	6.267 * 5.400 * † 8.875 †† 0.050	0.533 0.576 8.825 0	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	6.63
	Fish	BS S50 PC Day 0	2.967 * 3.400 * †† 0.050 †† 0.050	0.201 0.248 -- 0	6 4 1 3	*t*-tests	0.929
PCB 170+190 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	3.533 * 5.967 * 2.500 †† 0.050	0.350 0.433 1.222 0	6 6 3 3	*t*-tests	1.98
	Clam	BS S50 PC Day 0	7.433 * 6.900 * 5.200 † 0.717	0.674 0.374 3.400 0.390	6 6 2 3	*t*-tests	3.25
	Fish	BS S50 PC Day 0	† 0.808 * 1.150 * †† 0.050 †† 0.050	0.181 0.087 -- 0	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	0.689

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Table A14 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
PCB 172+197 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.288 †† 0.050 6.500 * †† 0.050	0.160 0 2.466 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	2.83
	Clam	BS S50 PC Day 0	† 0.158 † 0.233 † 1.575 †† 0.050	0.108 0.139 1.525 0	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	1.19
	Fish	BS S50 PC Day 0	† 0.192 † 0.188 †† 0.050 †† 0.050	0.142 0.138 – 0	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	0.605
PCB 173 (ng/g wet wt.)	Mussel	BS S50 Day 0	7.067 † 6.442 1.733	0.920 1.365 0.203	6 6 3	Nonparametric Dunnett's test (data converted to rankits)	4.07
	Fish	BS S50 Day 0	† 0.142 ** † 0.188 ** 1.133	0.092 0.138 0.120	6 4 3	Nonparametric *t*-tests (data converted to rankits)	0.411
PCB 174 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	†† 0.050 †† 0.050 † 0.500 †† 0.050	0 0 0.450 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.511
	Clam	BS S50 PC Day 0	†† 0.050 †† 0.050 5.750 †† 0.050	0 0 4.450 0	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	3.16
PCB 175 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 0.217 †† 0.050 † 30.700 † 0.200	0.106 0 30.650 0.150	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	34.8
	Clam	BS S50 PC Day 0	† 0.250 † 0.217 † 20.825 †† 0.050	0.127 0.106 20.775 0	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	14.8
PCB 177 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	2.917 * 3.233 * 3.467 †† 0.050	0.665 0.272 1.239 0	6 6 3 3	*t*-tests	2.30
	Clam	BS S50 PC Day 0	1.350 * 0.800 * 8.500 †† 0.050	0.131 0.086 4.200 0	6 6 2 3	*t*-tests	3.02

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Table A14 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
PCB 178 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	†† 0.050 † 33.258 * 30.967 †† 0.050	0 7.575 17.833 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	27.9
	Clam	BS S50 PC Day 0	†† 0.100 †† 0.100 † 2.075 †† 0.100	0 0 2.025 0	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	1.44
	Fish	BS S50 PC Day 0	†† 0.100 † 0.600 7.500 † 1.600	0 0.500 – 1.500	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	2.70
PCB 180 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	† 1.600 † 1.317 † 10.433 †† 0.200	0.445 0.510 8.223 0	6 6 3 3	*t*-tests (log-transformed data)	9.49
	Clam	BS S50 PC Day 0	† 1.267 †† 0.200 † 1.150 †† 0.200	0.479 0 0.950 0	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	1.48
PCB 183 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	1.283 * 0.883 * † 0.567 †† 0.050	0.192 0.054 0.517 0	6 6 3 3	*t*-tests	0.775
PCB 183 (continued)	Clam	BS S50 PC Day 0	† 0.450 † 0.092 † 1.075 †† 0.050	0.128 0.042 1.025 0	6 6 2 3	*t*-tests (log-transformed data)	0.817
	Fish	BS S50 PC Day 0	† 0.142 †† 0.050 5.400 † 0.167	0.092 0 – 0.117	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	0.384
PCB 185 (ng/g wet wt.)	Clam	BS S50 PC Day 0	†† 0.050 †† 0.050 4.025 †† 0.050	0 0 3.975 0	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	2.83
	Fish	BS S50 PC Day 0	† 0.192 †† 0.050 3.700 †† 0.050	0.142 0 – 0	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	0.516

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Table A14 (Continued)							
Contaminant	**Organism**	**Treatment**	**Mean Concentration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**Dunnett d_{min} [1]**
PCB 187+182 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	2.083 * 1.917 * † 4.267 †† 0.050	0.206 0.075 2.258 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	2.62
	Clam	BS S50 PC Day 0	1.183 * 0.783 * † 5.750 †† 0.050	0.147 0.095 5.550 0	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	3.97
	Fish	BS S50 PC Day 0	† 0.142 ** †† 0.050 ** † 0.200 1.667	0.092 0 – 0.426	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	0.769
PCB 191 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	†† 0.050 †† 0.050 † 0.783 †† 0.050	0 0 0.394 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.447
	Clam	BS S50 PC Day 0	†† 0.050 † 0.108 2.350 †† 0.050	0 0.058 1.750 0	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	1.25
	Fish	BS S50 PC Day 0	† 0.375 †† 0.050 2.800 † 0.133	0.325 0 – 0.083	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	1.19
PCB 193 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	†† 0.050 †† 0.050 † 0.433 †† 0.050	0 0 0.383 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.435
	Clam	BS S50 PC Day 0	†† 0.050 †† 0.050 † 7.225 †† 0.050	0 0 7.175 0	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	5.10
	Fish	BS S50 PC Day 0	† 0.175 ** †† 0.050 ** 2.800 1.767	0.125 0 – 0.088	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	0.477
PCB 194 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	†† 0.050 † 0.158 † 0.367 †† 0.050	0 0.108 0.317 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	0.452
	Clam	BS S50 PC Day 0	† 0.758 * † 0.433 4.450 †† 0.050	0.157 0.128 2.350 0	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	1.76

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Table A14 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
PCB 198 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	0.983 * 0.900 * † 2.350 †† 0.050	0.122 0.103 1.343 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.58
	Clam	BS S50 PC Day 0	† 0.600 † 0.217 †† 0.050 †† 0.050	0.211 0.106 0 0	6 6 2 3	*t*-tests (log-transformed data)	0.650
	Fish	BS S50 PC Day 0	† 0.142 †† 0.050 9.600 †† 0.050	0.092 0 – 0	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	0.334
PCB 199 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	†† 0.050 †† 0.050 † 1.783 †† 0.050	0 0 0.923 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.05
	Clam	BS S50 PC Day 0	†† 0.050 †† 0.050 † 3.475 †† 0.050	0 0 3.425 0	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	2.43
	Fish	BS S50 PC Day 0	† 0.192 †† 0.050 †† 0.050 †† 0.050	0.142 0 – 0	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	0.516
PCB 201 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	†† 0.050 †† 0.050 † 3.233 * †† 0.050	0 0 3.033 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	3.44
	Clam	BS S50 PC Day 0	† 0.217 †† 0.050 7.350 †† 0.050	0.106 0 4.450 0	6 6 2 3	Nonparametric *t*-tests (data converted to rankits)	3.18

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Table A14 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
PCB 202+171 (ng/g wet wt.)	Mussel	BS	1.300 *	0.155	6	*t*-tests	0.747
		S50	0.900 *	0.167	6		
		PC	† 0.467	0.417	3		
		Day 0	†† 0.050	0	3		
	Clam	BS	1.083 *	0.117	6	Nonparametric *t*-tests (data converted to rankits)	4.28
		S50	† 0.775 *	0.153	6		
		PC	† 6.025	5.975	2		
		Day 0	†† 0.050	0	3		
	Fish	BS	†† 0.050 **	0	6	Nonparametric *t*-tests (data converted to rankits)	0.687
		S50	† 0.263 **	0.213	4		
		PC	7.300	–	1		
		Day 0	5.933	0.296	3		
PCB 203+196 (ng/g wet wt.)	Mussel	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	2.19
		S50	†† 0.050	0	6		
		PC	† 2.133 *	1.933	3		
		Day 0	†† 0.050	0	3		
	Clam	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	1.15
		S50	† 0.400	0.227	6		
		PC	† 1.550	1.350	2		
		Day 0	†† 0.050	0	3		
PCB 205 (ng/g wet wt.)	Mussel	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	0.774
		S50	†† 0.050	0	6		
		PC	† 1.150	0.683	3		
		Day 0	†† 0.050	0	3		
	Clam	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	3.36
		S50	† 0.092	0.042	6		
		PC	† 4.775	4.725	2		
		Day 0	†† 0.050	0	3		
PCB 207 (ng/g wet wt.)	Clam	BS	†† 0.050	0	6	Nonparametric *t*-tests (data converted to rankits)	0.342
		S50	† 0.108	0.058	6		
		PC	† 0.475	0.425	2		
		Day 0	†† 0.050	0	3		

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Table A14 (Concluded)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	Dunnett d_{min}[1]
PCB 208+195 (ng/g wet wt.)	Mussel	BS S50 PC Day 0	†† 0.050 †† 0.050 4.433 * †† 0.050	0 0 1.592 0	6 6 3 3	Nonparametric *t*-tests (data converted to rankits)	1.81
	Clam	BS S50 PC Day 0	† 0.408 † 0.175 † 1.025 †† 0.050	0.188 0.125 0.975 0	6 6 2 3	*t*-tests (log-transformed data)	0.930
	Fish	BS S50 PC Day 0	†† 0.050 ** † 0.863 9.700 0.600	0 0.813 – 0.115	6 4 1 3	Nonparametric *t*-tests (data converted to rankits)	1.88
Lipid (percent wet wt.)	Mussel	BS S50 PC Day 0	1.496 1.636 1.296 1.857	0.108 0.073 0.071 0.249	6 6 3 3	*t*-tests	0.442
	Clam	BS S50 PC Day 0	2.994 3.075 2.747 3.229	0.606 0.493 0.342 0.350	6 6 2 3	Dunnett's test (log-transformed data)	2.21
	Fish[4]	BS S50 Day 0	1.184 ** 1.384 1.660	0.060 0.153 0.022	6 4 3	Nonparametric Dunnett's test (data converted to rankits)	0.342

Table A15.
Descriptive Statistics and Statistical Comparisons of Contaminant Bioaccumulation and Lipid in Fish (*Citharichthys stigmaeus*), Clams (*Macoma nasuta*), and Mussels (*Mytilus edulis*) Exposed to Oakland Hot Sediment for 28 Days

Contaminant	Organism	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
Acenaphthene (ng/g wet wt.)	Clam	† 39.811[2] A[3]	7.744	14	Nonparametric *t*-tests (data converted to rankits)	12.7
	Mussel	† 5.593 B	0.772	15		
	Fish	†† 1.373 C	0.283	11		
Acenaphthylene (ng/g wet wt.)	Mussel	† 6.984 A	1.107	15	Nonparametric *t*-tests (data converted to rankits)	1.64
	Clam	† 0.380 B	0.153	14		
	Fish	†† 0.240 B	0.044	11		
Anthracene (ng/g wet wt.)	Clam	† 193.954 A	28.999	14	Nonparametric *t*-tests (data converted to rankits)	45.3
	Mussel	† 22.529 B	4.636	15		
	Fish	† 1.750 B	0.828	11		
Benz[a]anthracene (ng/g wet wt.)	Clam	† 404.314 A	50.014	14	*t*-tests	98.0
	Mussel	† 331.736 A	68.205	15		
	Fish	† 6.829 B	3.992	11		
Benzo[a]pyrene (ng/g wet wt.)	Mussel	† 340.183 A	67.269	15	*t*-tests	92.3
	Clam	† 299.476 A	38.647	14		
	Fish	† 3.128 B	1.881	11		
Benzo[b]fluoranthene (ng/g wet wt.)	Mussel	† 503.354 A	93.048	15	*t*-tests	125
	Clam	† 391.240 A	50.197	14		
	Fish	† 6.771 B	4.148	11		
Benzo[k]fluoranthene (ng/g wet wt.)	Mussel	† 231.954 A	43.615	15	*t*-tests	60.0
	Clam	† 186.382 A	24.404	14		
	Fish	† 4.766 B	3.078	11		
Benzo[g,h,i]-perylene (ng/g wet wt.)	Mussel	† 99.030 A	18.286	15	*t*-tests	26.4
	Clam	† 93.192 A	12.548	14		
	Fish	† 0.819 B	0.364	11		
Chrysene (ng/g wet wt.)	Clam	† 568.738 A	70.374	14	*t*-tests	136
	Mussel	† 514.287 A	98.396	15		
	Fish	† 5.185 B	3.151	11		
Dibenz[a,h]anthracene (ng/g wet wt.)	Clam	† 22.042 A	2.893	14	*t*-tests	4.81
	Mussel	† 11.598 B	2.278	15		
	Fish	†† 1.149 C	0.267	11		
Dibenzothiophene (ng/g wet wt.)	Clam	† 36.831 A	5.658	14	Nonparametric *t*-tests (data converted to rankits)	8.87
	Mussel	† 4.904 B	0.978	15		
	Fish	†† 1.244 C	0.261	11		

[1] Minimum significant difference that can be detected by LSD test on untransformed data.
[2] † Mean includes at least one concentration less than DL and set equal to DL/10;
†† *All concentrations less than DL and set equal to DL/10.*
[3] For a given contaminant, means followed by the same letter are not significantly different from each other (two-tailed test, $\alpha/2 = 0.025$).
[4] One outlier (Fish positive control) deleted.

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Table A15 (Continued)						
Contaminant	**Organism**	**Mean Concentration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**LSD d_{min}[1]**
Fluoranthene (ng/g wet wt.)	Clam Mussel Fish	1567.38 A † 554.55 B † 11.66 C	197.315 118.860 6.922	14 15 11	Nonparametric LSD test (data converted to rankits)	287
Fluorene (ng/g wet wt.)	Clam Mussel Fish	† 25.102 A † 4.771 B †† 1.295 C	3.859 0.573 0.269	14 15 11	Nonparametric *t*-tests (data converted to rankits)	6.23
Indeno[1,2,3-cd]pyrene (ng/g wet wt.)	Mussel Clam Fish	† 75.160 A † 67.707 A † 1.261 B	14.905 9.084 0.353	15 14 11	*t*-tests	21.5
Naphthalene (ng/g wet wt.)	Fish Clam Mussel	61.082 A 53.664 A 49.293 A	6.576 5.150 4.966	11 14 15	LSD test	9.99
Phenanthrene (ng/g wet wt.)	Clam Mussel Fish	538.408 A 78.063 B 28.628 C	78.780 13.844 3.701	14 15 11	Nonparametric *t*-tests (data converted to rankits)	124
Pyrene (ng/g wet wt.)	Clam Mussel Fish	† 1589.59 A † 683.90 B † 9.11 C	202.376 167.183 6.108	14 15 11	Nonparametric *t*-tests (data converted to rankits)	323
Cd (µg/g dry wt.)	Mussel Clam Fish	11.771 A 0.454 B 0.404 B	3.255 0.150 0.041	15 14 13	Nonparametric LSD test (data converted to rankits)	4.86
Cr (µg/g dry wt.)	Clam Mussel Fish	4.379 A 3.327 B 0.873 C	0.491 0.368 0.075	14 15 13	LSD test (log-transformed data)	0.893
Hg (µg/g dry wt.)	Mussel Fish Clam	0.293 A 0.267 A 0.152 B	0.007 0.032 0.007	15 13 14	*t*-tests (log-transformed data)	0.0538
TBT (ng/g wet wt.)	Mussel Clam Fish	66.286 A 21.175 B † 7.685 AB	8.775 1.818 2.248	14 12 4	*t*-tests (log-transformed data)	20.4
DBT (ng/g wet wt.)	Mussel Clam Fish	13.250 A † 3.528 B †† 0.768 C	1.721 0.437 0.176	14 12 4	Nonparametric LSD test (data converted to rankits)	3.83
MBT (ng/g wet wt.)	Fish Mussel Clam	†† 1.293 A † 0.506 A †† 0.453 A	0.295 0.084 0.035	4 14 12	Nonparametric LSD test (data converted to rankits)	0.273
α-Chlordane (ng/g wet wt.)	Mussel Clam	8.150 A †† 0.500 A	1.350 0	2 2	*t*-test	5.81
γ-Chlordane (ng/g wet wt.)	Mussel Clam	11.850 A † 2.900 A	1.050 2.400	2 2	*t*-test	11.3
DDE (ng/g wet wt.)	Mussel Clam	76.150 A † 10.850 A	60.750 10.350	2 2	*t*-test	265
						(Sheet 2 of 8)

Table A15 (Continued)

Contaminant	Organism	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
DDD (ng/g wet wt.)	Mussel Clam	3455.1 A 368.9 A	1322.5 356.3	2 2	*t*-test (log-transformed data)	5893
DDT (ng/g wet wt.)	Mussel Clam	1360.85 A 381.00 A	317.25 366.30	2 2	*t*-test (log-transformed data)	2085
Aroclor 1254 (ng/g wet wt.)	Mussel Fish Clam	† 71.464 A 44.714 AB † 23.000 B	9.607 2.925 21.000	14 7 3	*t*-tests	15.9
PCB 8+5 (ng/g wet wt.)	Fish Clam Mussel	† 83.082 A † 4.121 A † 2.473 A	53.620 1.425 1.096	11 14 15	Nonparametric *t*-tests (data converted to rankits)	72.8
PCB 17 (ng/g wet wt.)	Clam Fish Mussel	† 5.389 A † 1.768 B † 1.313 B	0.981 0.867 0.273	14 11 15	Nonparametric LSD test (data converted to rankits)	2.19
PCB 18 (ng/g wet wt.)	Mussel Fish Clam	† 2.463 A † 1.568 AB † 1.036 B	0.842 0.765 0.518	15 11 14	*t*-tests (log-transformed data)	1.24
PCB 19 (ng/g wet wt.)	Clam Fish Mussel	† 2.457 A † 1.827 A † 1.033 A	0.589 1.285 0.460	14 11 15	Nonparametric *t*-tests (data converted to rankits)	1.50
PCB 22 (ng/g wet wt.)	Clam Mussel Fish	† 7.961 A † 4.723 B † 2.073 C	0.937 0.669 0.628	14 15 11	LSD test	2.21
PCB 25 (ng/g wet wt.)	Mussel Clam Fish	6.247 A † 3.121 B † 1.177 C	0.773 0.948 0.520	15 14 11	*t*-tests (log-transformed data)	2.24
PCB 26 (ng/g wet wt.)	Clam Fish Mussel	† 3.318 A † 3.009 A † 1.953 A	2.480 1.052 0.592	14 11 15	Nonparametric LSD test (data converted to rankits)	3.88
PCB 27 (ng/g wet wt.)	Clam Fish Mussel	8.800 A 4.700 A 4.133 A	6.600 -- 1.299	2 1 3	*t*-tests	18.1
PCB 29 (ng/g wet wt.)	Fish Clam Mussel	† 0.459 A † 0.271 A † 0.100 A	0.366 0.098 0.050	11 14 15	Nonparametric *t*-tests (data converted to rankits)	0.549
PCB 31+28 (ng/g wet wt.)	Clam Fish Mussel	9.000 A † 6.182 A 6.133 A	1.640 0.794 2.360	14 11 3	Nonparametric LSD test (data converted to rankits)	4.09
PCB 32+16 (ng/g wet wt.)	Clam Fish Mussel	† 3.657 A † 3.655 A † 3.413 A	1.951 2.051 0.476	14 11 15	*t*-tests (log-transformed data)	3.62

(Sheet 3 of 8)

Table A15 (Continued)

Contaminant	Organism	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 33 and PCB 33+53 (µg/g dry wt.)	Fish	† 6.495 A	1.525	11	Nonparametric *t*-tests (data converted to rankits)	2.61
	Clam	† 1.508 AB	0.911	12		
	Mussel	† 0.767 B	0.345	15		
PCB 40 (µg/g dry wt.)	Mussel	† 4.280 A	1.917	15	Nonparametric *t*-tests (data converted to rankits)	4.51
	Clam	† 2.961 B	2.513	14		
	Fish	† 1.382 B	0.954	11		
PCB 42+37 (µg/g dry wt.)	Clam	† 4.521 B	2.914	14	Nonparametric LSD test (data converted to rankits)	3.09
	Mussel	† 4.020 A	1.702	15		
	Fish	† 2.009 B	1.576	11		
PCB 44 (µg/g dry wt.)	Mussel	† 2.750 A	0.307	15	LSD test	0.229
	Clam	† 1.746 B	0.375	14		
	Fish	† 0.627 C	0.287	11		
PCB 45 (µg/g dry wt.)	Clam	† 3.861 A	0.498	14	*t*-tests	1.14
	Mussel	† 2.473 A	0.183	15		
	Fish	† 2.273 A	0.453	11		
PCB 46 (µg/g dry wt.)	Clam	† 2.443 A	1.239	14	Nonparametric *t*-tests (data converted to rankits)	2.84
	Fish	† 2.325 A	2.275	2		
	Mussel	† 0.520 A	0.301	15		
PCB 48+47 (µg/g dry wt.)	Fish	† 7.325 A	7.275	2	Nonparametric *t*-tests (data converted to rankits)	2.78
	Mussel	† 2.353 A	0.798	15		
	Clam	† 0.913 A	0.863	4		
PCB 49 and PCB 49+33 (ng/g wet wt.)	Clam	4.964 A	1.905	14	Nonparametric LSD test (data converted to rankits)	3.40
	Mussel	† 3.590 A	0.332	15		
	Fish	† 3.386 A	0.639	11		
PCB 52 (ng/g wet wt.)	Mussel	† 5.383 A	2.674	3	*t*-tests	12.4
	Fish	3.600 A	–	1		
	Clam	† 1.225 A	1.175	2		
PCB 56+60 (ng/g wet wt.)	Clam	† 4.782 A	2.359	14	Nonparametric LSD test (data converted to rankits)	3.46
	Mussel	4.647 A	1.596	15		
	Fish	† 0.282 B	0.157	11		
PCB 63 (ng/g wet wt.)	Fish	† 4.045 A	0.871	11	LSD test	1.70
	Mussel	† 3.817 A	0.511	15		
	Clam	† 2.218 A	0.510	14		
PCB 64+41+71 (ng/g wet wt.)	Clam	† 2.310 A	2.021	10	Nonparametric *t*-tests (data converted to rankits)	3.92
	Fish	† 2.036 A	0.613	11		
	Mussel	† 1.050 A	0.850	4		
PCB 70+76 (ng/g wet wt.)	Mussel	† 3.493 A	0.429	15	LSD test	1.14
	Clam	† 3.193 A	0.383	14		
	Fish	† 0.800 B	0.429	11		

(Sheet 4 of 8)

Table A15 (Continued)

Contaminant	Organism	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min} [1]
PCB 74 (ng/g wet wt.)	Clam Fish Mussel	† 2.304 A † 1.568 A † 1.473 A	1.517 0.809 0.252	14 11 15	Nonparametric LSD test (data converted to rankits)	2.57
PCB 82 (ng/g wet wt.)	Clam Mussel Fish	25.307 A † 2.397 B † 1.541 C	5.618 0.752 1.089	14 15 11	*t*-tests (log-transformed data)	8.79
PCB 83 (ng/g wet wt.)	Mussel Fish Clam	† 1.213 A † 0.825 AB † 0.629 B	0.192 0.131 0.124	12 10 12	LSD test	0.431
PCB 84 and PCB 92+84 (ng/g wet wt.)	Mussel Clam Fish	† 2.723 A † 1.836 B † 0.832 B	0.444 1.058 0.186	15 14 11	Nonparametric LSD test (data converted to rankits)	1.90
PCB 85 (ng/g wet wt.)	Mussel Fish Clam	† 16.977 AB 7.018 A † 5.286 B	10.899 0.485 2.049	15 11 14	Nonparametric *t*-tests (data converted to rankits)	18.8
PCB 87 (ng/g wet wt.)	Mussel Clam Fish	2.460 A † 1.871 B † 1.477 B	0.235 0.674 0.375	15 14 11	Nonparametric LSD test (data converted to rankits)	1.24
PCB 91 (ng/g wet wt.)	Mussel Clam Fish	2.140 A † 1.007 B † 0.609 B	0.162 0.776 0.332	15 14 11	Nonparametric *t*-tests (data converted to rankits)	1.32
PCB 95+66 (ng/g wet wt.)	Clam Fish Mussel	27.150 A † 7.782 A † 5.800 A	17.850 1.560 2.859	2 11 3	*t*-tests	11.2
PCB 97 (ng/g wet wt.)	Mussel Fish Clam	2.367 A † 1.414 A † 1.125 A	0.614 0.869 1.075	15 11 2	Nonparametric *t*-tests (data converted to rankits)	1.17
PCB 99 (ng/g wet wt.)	Mussel Fish Clam	† 2.337 A † 1.259 B † 1.143 B	0.336 0.235 0.149	15 11 14	Nonparametric LSD test (data converted to rankits)	0.758
PCB 100 (ng/g wet wt.)	Clam Mussel Fish	† 4.604 A † 0.993 A † 0.964 A	3.632 0.565 0.779	14 15 11	Nonparametric *t*-tests (data converted to rankits)	5.45
PCB 101 and PCB 101+89 (ng/g wet wt.)	Mussel Clam Fish	5.433 A 5.157 A 3.336 B	0.530 0.652 0.519	15 14 11	LSD test	1.69
PCB 107 (ng/g wet wt.)	Mussel Fish Clam	† 0.488 A † 0.340 AB † 0.096 B	0.079 0.119 0.046	12 10 12	*t*-tests	0.241

(CSheet 5 of 8)

Table A15 (Continued)

Contaminant	Organism	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 110 and PCB 110+77 (ng/g wet wt.)	Mussel Clam Fish	† 7.933 A † 6.379 A † 3.195 B	1.122 0.809 0.492	15 14 11	Nonparametric *t*-tests (data converted to rankits)	1.45
PCB 118 and PCB 118+149 (ng/g wet wt.)	Mussel Clam Fish	4.533 A 3.464 AB 2.291 B	0.595 0.507 0.209	15 14 11	*t*-tests	1.35
PCB 128 (ng/g wet wt.)	Mussel Clam Fish	† 1.463 A † 0.771 B †† 0.050 C	0.301 0.265 0	15 14 11	Nonparametric *t*-tests (data converted to rankits)	0.641
PCB 131 (ng/g wet wt.)	Mussel Clam Fish	† 0.721 A † 0.088 B †† 0.050 B	0.173 0.038 0	12 12 10	Nonparametric *t*-tests (data converted to rankits)	0.288
PCB 134+114 (ng/g wet wt.)	Mussel Clam Fish	5.717 A 1.967 B 1.630 B	0.816 0.278 0.460	12 12 10	LSD test (log-transformed data)	1.51
PCB 135+144 (ng/g wet wt.)	Fish Mussel Clam	† 2.705 A † 0.710 A † 0.500 A	0.865 0.219 0.237	11 15 8	*t*-tests (log-transformed data)	1.43
PCB 136 (ng/g wet wt.)	Clam Mussel Fish	† 6.800 B † 6.020 A † 0.155 B	5.329 1.153 0.105	14 15 11	Nonparametric *t*-tests (data converted to rankits)	8.11
PCB 137+176 (ng/g wet wt.)	Mussel Clam Fish	† 1.737 A † 0.289 B †† 0.050 B	0.236 0.239 0	15 14 11	Nonparametric *t*-tests (data converted to rankits)	0.610
PCB 141 (ng/g wet wt.)	Fish Clam Mussel	† 3.055 A † 2.557 A †† 0.280 B	0.477 0.270 0.011	11 14 15	Nonparametric *t*-tests (data converted to rankits)	0.756
PCB 146 (ng/g wet wt.)	Fish Clam Mussel	† 2.886 A † 2.371 A † 1.720 A	0.568 0.282 0.478	11 14 15	*t*-tests	1.25
PCB 149 (ng/g wet wt.)	Mussel Clam Fish	5.867 A 2.942 B † 1.685 C	0.481 0.248 0.195	12 12 10	*t*-tests	1.00
PCB 151 (ng/g wet wt.)	Mussel Clam Fish	† 1.550 A † 0.850 B † 0.477 B	0.223 0.128 0.090	15 14 11	LSD test	0.485
PCB 153+132+105 (ng/g wet wt.)	Mussel Clam Fish	† 22.22 A † 8.743 AB 7.073 B	10.168 1.292 2.549	15 14 11	Nonparametric LSD test (*data converted to rankits*)	18.7
PCB 157+200 (ng/g wet wt.)	Mussel Clam Fish	† 1.317 A † 0.321 B † 0.286 B	0.461 0.232 0.103	15 14 11	Nonparametric *t*-tests (data converted to rankits)	0.773

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Table A15 (Continued)						
Contaminant	Organism	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min} [1]
PCB 158 (ng/g wet wt.)	Mussel Fish Clam	2.287 A † 1.291 B † 0.418 B	0.385 1.086 0.180	15 11 14	Nonparametric *t*-tests (data converted to rankits)	1.40
PCB 163+138 (ng/g wet wt.)	Mussel Clam Fish	† 7.293 A † 6.268 A † 2.859 B	0.984 1.028 0.317	15 14 11	Nonparametric *t*-tests (data converted to rankits)	2.48
PCB 170+190 (ng/g wet wt.)	Clam Mussel Fish	6.886 A 4.300 B † 0.864 C	0.516 0.479 0.138	14 15 11	*t*-tests	1.15
PCB 172+197 (ng/g wet wt.)	Mussel Clam Fish	† 1.435 A † 0.393 A † 0.177 A	0.798 0.221 0.088	15 14 11	Nonparametric *t*-tests (data converted to rankits)	1.21
PCB 173 (ng/g wet wt.)	Mussel Fish Clam	† 6.754 A † 0.160 B †† 0.050 B	0.791 0.073 0	12 10 12	Nonparametric *t*-tests (data converted to rankits)	1.42
PCB 174 (ng/g wet wt.)	Clam Mussel Fish	† 0.864 A † 0.140 A †† 0.050 A	0.724 0.090 0	14 15 11	Nonparametric *t*-tests (data converted to rankits)	1.14
PCB 175 (ng/g wet wt.)	Mussel Fish Clam	† 6.247 A † 5.782 A † 3.175 A	6.125 5.732 2.957	15 11 14	Nonparametric *t*-tests (data converted to rankits)	11.6
PCB 177 (ng/g wet wt.)	Mussel Clam Fish	3.153 A 2.136 B † 1.445 C	0.347 0.850 1.395	15 14 11	Nonparametric *t*-tests (data converted to rankits)	1.97
PCB 178 (ng/g wet wt.)	Mussel Fish Clam	† 19.517 A † 0.955 A † 0.382 A	5.948 0.679 0.286	15 11 14	Nonparametric *t*-tests (data converted to rankits)	10.2
PCB 180 (ng/g wet wt.)	Mussel Clam Fish	† 3.253 A † 0.793 A † 0.764 A	1.709 0.261 0.564	15 14 11	Nonparametric *t*-tests (data converted to rankits)	2.98
PCB 183 (ng/g wet wt.)	Mussel Fish Clam	† 0.980 A † 0.586 B † 0.386 B	0.137 0.484 0.151	15 11 14	LSD test (log-transformed data)	0.708
PCB 185 (ng/g wet wt.)	Clam Fish Mussel	† 0.618 A † 0.459 A †† 0.050 A	0.568 0.333 0	14 11 15	Nonparametric *t*-tests (data converted to rankits)	0.947
PCB 187+182 (ng/g wet wt.)	Mussel Clam Fish	† 2.453 A † 1.664 B † 0.114 C	0.460 0.748 0.050	15 14 11	Nonparametric *t*-tests (data converted to rankits)	1.39

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Table A15 (Concluded)

Contaminant	Organism	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 191 (ng/g wet wt.)	Fish	† 0.477 A	0.292	11	Nonparametric *t*-tests (data converted to rankits)	0.497
	Clam	† 0.404 A	0.288	14		
	Mussel	† 0.197 A	0.103	15		
PCB 193 (ng/g wet wt.)	Clam	† 1.075 A	1.025	14	Nonparametric *t*-tests (data converted to rankits)	1.63
	Fish	† 0.368 A	0.252	11		
	Mussel	† 0.127 A	0.077	15		
PCB 194 (ng/g wet wt.)	Clam	† 1.146 A	0.457	14	Nonparametric *t*-tests (data converted to rankits)	0.781
	Fish	† 0.509 B	0.459	11		
	Mussel	† 0.157 B	0.074	15		
PCB 198 (ng/g wet wt.)	Mussel	† 1.223 A	0.279	15	Nonparametric *t*-tests (data converted to rankits)	1.15
	Fish	† 0.968 B	0.865	11		
	Clam	† 0.357 B	0.113	14		
PCB 199 (ng/g wet wt.)	Clam	† 0.539 A	0.489	14	Nonparametric *t*-tests (data converted to rankits)	0.806
	Mussel	† 0.397 A	0.242	15		
	Fish	† 0.127 A	0.077	11		
PCB 201 (ng/g wet wt.)	Clam	† 1.164 A	0.843	14	Nonparametric *t*-tests (data converted to rankits)	1.50
	Mussel	† 0.687 A	0.615	15		
	Fish	†† 0.064 A	0.014	11		
PCB 202+171 (ng/g wet wt.)	Clam	† 1.657 A	0.803	14	Nonparametric LSD test (data converted to rankits)	1.52
	Mussel	† 0.973 A	0.139	15		
	Fish	† 0.786 B	0.656	11		
PCB 203+196 (ng/g wet wt.)	Mussel	† 0.467 A	0.395	15	Nonparametric *t*-tests (data converted to rankits)	0.733
	Clam	† 0.414 A	0.217	14		
	Fish	†† 0.064 A	0.014	11		
PCB 205 (ng/g wet wt.)	Clam	† 0.743 A	0.674	14	Nonparametric *t*-tests (data converted to rankits)	1.04
	Fish	† 0.400 A	0.350	11		
	Mussel	† 0.270 A	0.165	15		
PCB 208+195 (ng/g wet wt.)	Fish	† 1.223 A	0.897	11	Nonparametric *t*-tests (data converted to rankits)	1.13
	Mussel	† 0.927 A	0.540	15		
	Clam	† 0.396 A	0.157	14		
Lipid[4] (percent wet wt.)	Clam	2.993 A	0.321	15	*t*-tests (log-transformed data)	0.603
	Mussel	1.512 B	0.061	14		
	Fish	1.264 C	0.073	10		

Table A16.
Oakland Hot Sediment: Descriptive Statistics and Statistical Comparisons of Contaminant Bioaccumulation and Lipid from 28-Day Exposures to Bedded Sediment (BS) vs. 28-Day Exposures to 50 mg/L Suspended Sediment (S50)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
Acenaphthene (ng/g wet wt.)	Mussel	BS S50	5.332 8.333 *[2]	0.161 0.378	6 6	*t*-test (log-transformed data)	0.916
	Clam	BS S50	53.167 † 39.600[3]	10.725 10.460	6 6	*t*-test	33.4
	All	BS S50	† 19.807 † 18.546	6.648 5.639	18 16	Wilcoxon Rank-Sum test	18.0
Acenaphthylene (ng/g wet wt.)	Mussel	BS S50	6.118 11.127 *	0.577 0.597	6 6	*t*-test	1.85
	Clam	BS S50	† 0.452 †† 0.367	0.330 0.174	6 6	Wilcoxon Rank-Sum test	0.831
	All	BS S50	† 2.241 † 4.404	0.6[illegible]7 1.363	18 16	Wilcoxon Rank-Sum test	3.02
Anthracene (ng/g wet wt.)	Mussel	BS S50	13.783 42.467 *	1.187 2.027	6 6	*t*-test	5.23
	Clam	BS S50	236.833 215.650	24.055 39.486	6 6	*t*-test	103
	Fish	BS S50	† 2.500 †† 1.000	1.500 0	6 4	Wilcoxon Rank-Sum test	4.32
	All	BS S50	† 84.372 † 97.044	27.240 27.844	18 16	Wilcoxon Rank-Sum test	79.5
Benz[a]anthracene (ng/g wet wt.)	Mussel	BS S50	206.667 622.500 *	27.083 28.477	6 6	*t*-test	87.6
	Clam	BS S50	451.833 491.500	27.057 39.798	6 6	*t*-test	107
	Fish	BS S50	† 4.418 † 12.105	3.317 10.134	6 4	Wilcoxon Rank-Sum test	20.8
	All	BS S50	† 220.973 † 420.776 *	45.971 65.041	18 16	Wilcoxon Rank-Sum test	160
Benzo[a]pyrene (ng/g wet wt.)	Mussel	BS S50	234.667 615.333 *	38.984 35.738	6 6	*t*-test	118
	Clam	BS S50	319.667 378.833	25.534 33.503	6 6	*t*-test	93.9

[1] Minimum significant difference that can be detected by LSD test on untransformed data.
[2] * Indicates a treatment that is significantly greater than the other treatment (two-tailed test, $\alpha/2 = 0.025$).
[3] † Mean includes at least one concentration less than DL and set equal to DL/10;
†† All concentrations less than DL and set equal to DL/10. Contaminants for which both treatments for a given organism were less than DL are not included in the table.

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Table A16 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
Benzo[a]pyrene (continued)	Fish	BS S50	† 2.261 † 5.170	1.928 4.544	6 4	Wilcoxon Rank-Sum test	9.98
	All	BS S50	† 185.531 † 374.105 *	35.665 63.442	18 16	*t*-test	144
Benzo[b]fluoranthene (ng/g wet wt.)	Mussel	BS S50	386.833 871.500 *	56.133 48.028	6 6	*t*-test	165
	Clam	BS S50	425.167 487.667	34.985 42.157	6 6	*t*-test	122
	Fish	BS S50	† 4.873 † 11.266	4.226 10.046	6 4	Wilcoxon Rank-Sum test	22.0
	All	BS S50	† 272.291 † 512.504 *	50.481 89.108	18 16	*t*-test	203
Benzo[k]fluoranthene (ng/g wet wt.)	Mussel	BS S50	173.000 406.833 *	23.784 23.732	6 6	*t*-test	74.9
	Clam	BS S50	204.000 230.833	18.831 22.126	6 6	*t*-test	64.7
	Fish	BS S50	† 5.578 † 4.695	5.244 4.002	6 4	Wilcoxon Rank-Sum test	16.8
	All	BS S50	† 127.526 † 240.299 *	23.232 41.870	18 16	*t*-test	94.7
Benzo[g,h,i]-perylene (ng/g wet wt.)	Mussel	BS S50	75.317 171.833 *	9.642 10.550	6 6	*t*-test	31.8
	Clam	BS S50	100.117 116.933	10.586 12.506	6 6	*t*-test	36.5
	Fish	BS S50	† 0.673 †† 0.421	0.501 0.105	6 4	Wilcoxon Rank-Sum test	1.46
	All	BS S50	† 58.702 † 108.393 *	11.189 18.171	18 16	Wilcoxon Rank-Sum test	42.4
Chrysene (ng/g wet wt.)	Mussel	BS S50	360.677 924.833 *	39.491 37.142	6 6	*t*-test	121
	Clam	BS S50	629.667 696.833	40.512 54.232	6 6	*t*-test	151
	Fish	BS S50	† 4.417 † 7.589	3.997 6.837	6 4	Wilcoxon Rank-Sum test	17.0
	All	BS S50	† 331.583 † 610.022 *	64.599 96.215	18 16	Wilcoxon Rank-Sum test	231

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Table A16 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
Dibenz[a,h]anthracene (ng/g wet wt.)	Mussel	BS S50	12.228 16.708	1.905 3.769	6 6	*t*-test	9.41
	Clam	BS S50	24.800 26.567	3.156 1.836	6 6	*t*-test	8.14
	All	BS S50	† 12.592 † 16.726	2.647 2.872	18 16	Wilcoxon Rank-Sum test	7.95
Dibenzothiophene (ng/g wet wt.)	Mussel	BS S50	2.942 9.135 *	0.212 0.484	6 6	*t*-test (log-transformed data)	1.18
	Clam	BS S50	43.417 42.450	5.669 7.596	6 6	*t*-test	21.1
	All	BS S50	† 15.737 † 19.865	5.073 5.306	18 16	Wilcoxon Rank-Sum test	15.0
Fluoranthene (ng/g wet wt.)	Mussel	BS S50	310.667 1075.167 *	25.289 38.953	6 6	*t*-test	103
	Clam	BS S50	1785.000 1870.833	112.183 181.128	6 6	*t*-test	475
	Fish	BS S50	† 12.721 † 12.935	11.494 9.845	6 4	Wilcoxon Rank-Sum test	37.7
	All	BS S50	† 702.80 † 1107.98	191.379 197.120	18 16	Wilcoxon Rank-Sum test	561
Fluorene (ng/g wet wt.)	Mussel	BS S50	4.575 6.770 *	0.066 0.368	6 6	*t*-test	0.834
	Clam	BS S50	32.283 † 24.912	4.131 5.719	6 6	*t*-test	15.7
	All	BS S50	† 12.581 † 12.420	3.637 3.251	18 16	Wilcoxon Rank-Sum test	10.0
Indeno[1,2,3-cd]pyrene (ng/g wet wt.)	Mussel	BS S50	51.550 136.000 *	7.560 9.578	6 6	*t*-test	27.2
	Clam	BS S50	71.950 85.250	7.334 9.828	6 6	*t*-test	27.3
	Fish	BS S50	† 1.065 †† 1.184	0.582 0.295	6 4	Wilcoxon Rank-Sum test	1.76
	All	BS S50	† 41.522 † 83.265 *	7.945 14.334	18 16	*t*-test	32.4

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Table A16 (Continued)

Contaminant	Organ-ism	Treat-ment	Mean Concen-tration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
Naphthalene (ng/g wet wt.)	Mussel	BS S50	58.533 57.933	1.716 3.096	6 6	*t*-test	7.89
	Clam	BS S50	65.917 53.567	2.077 6.127	6 6	*t*-test	14.4
	Fish	BS S50	53.350 80.850 *	3.099 11.103	6 4	*t*-test (log-transformed data)	22.1
	All	BS S50	59.267 62.025	1.794 4.491	18 16	*t*-test	9.44
Phenanthrene (ng/g wet wt.)	Mussel	BS S50	49.450 137.667 *	2.102 8.189	6 6	*t*-test (log-transformed data)	18.8
	Clam	BS S50	634.167 610.167	74.371 111.161	6 6	*t*-test	298
	Fish	BS S50	26.917 36.650	3.650 5.448	6 4	*t*-test	14.5
	All	BS S50	236.844 289.600	72.056 75.941	18 16	Wilcoxon Rank-Sum test	213
Pyrene (ng/g wet wt.)	Mussel	BS S50	294.17 1415.00 *	21.313 106.325	6 6	*t*-test (log-transformed data)	242
	Clam	BS S50	1750.00 958.33	101.915 194.258	6 6	*t*-test	489
	Fish	BS S50	† 11.783 † 7.325	10.783 6.325	6 4	Wilcoxon Rank-Sum test	33.2
	All	BS S50	† 685.32 † 1266.83 *	187.605 212.308	18 16	*t*-test	575
Cd (µg/g dry wt.)	Mussel	BS S50	6.527 6.752	0.399 0.347	6 6	*t*-test	1.18
	Clam	BS S50	0.310 0.279	0.041 0.034	6 6	*t*-test	0.119
	Fish	BS S50	0.480 * 0.274	0.018 0.022	6 6	*t*-test	0.064
	All	BS S50	2.439 2.435	0.712 0.748	18 18	Wilcoxon Rank-Sum test	2.10

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Table A16 (Continued)

Contaminant	Organ-ism	Treat-ment	Mean Concen-tration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
Cr (µg/g dry wt.)	Mussel	BS S50	4.017 3.600	0.605 0.291	6 6	*t*-test	1.50
	Clam	BS S50	5.517 3.817	0.733 0.606	6 6	*t*-test	2.12
	Fish	BS S50	0.990 0.778	0.059 0.142	6 6	*t*-test (log-transformed data)	0.343
	All	BS S50	3.508 2.732	0.545 0.399	18 18	Wilcoxon Rank-Sum test	1.37
Hg (µg/g dry wet)	Clam	BS S50	0.165 0.142	0.012 0.010	6 6	*t*-test	0.034
	Fish	BS S50	0.270 0.270	0.046 0.057	6 6	*t*-test	0.164
	All	BS S50	0.240 0.240	0.020 0.026	18 18	Wilcoxon Rank-Sum test	0.066
TBT (ng/g wet wt.)	Mussel	BS S50	77.083 40.480	16.057 2.843	6 5	*t*-test	40.6
	Clam	BS S50	19.440 23.567	2.573 2.723	5 6	*t*-test	8.60
	All	BS S50	42.079 31.255	10.720 3.253	14 11	*t*-test (log-transformed data)	25.8
DBT (ng/g wet wt.)	Mussel	BS S50	15.617 * 6.860	1.931 0.985	6 5	*t*-test	5.23
	Clam	BS S50	3.120 4.417	0.483 0.371	5 6	*t*-test	1.35
	All	BS S50	† 7.936 5.527	2.027 0.602	14 11	*t*-test	4.88
MBT (ng/g wet wt.)	Mussel	BS S50	† 0.635 †† 0.326	0.155 0.015	6 5	*t*-test	0.389
	All	BS S50	† 0.672 * † 0.375	0.088 0.031	14 11	*t*-test	0.214
Aroclor 1254 (ng/g wet wt.)	Mussel	BS S50	70.583 95.500 *	9.059 6.360	6 6	*t*-test	24.7
	Fish	BS S50	39.750 51.333 *	2.839 2.333	4 3	*t*-test	9.99
	All	BS S50	†58.250 †79.200	7.334 7.726	10 10	*t*-test	22.4

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Table A16 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min} [1]
PCB 8+5 (ng/g wet wt.)	Mussel	BS S50	2.717 * † 0.583	0.508 0.383	6 6	Wilcoxon Rank-Sum test	1.42
	Clam	BS S50	4.367 * † 1.717	0.784 0.722	6 6	*t*-test	2.38
	Fish	BS S50	† 148.367 † 5.875	93.022 5.675	6 4	*t*-test (log-transformed data)	268
	All	BS S50	† 51.817 * † 2.331	33.506 1.410	18 16	Wilcoxon Rank-Sum test	72.6
PCB 17 (ng/g wet wt.)	Mussel	BS S50	1.200 † 0.892	0.113 0.188	6 6	*t*-test	0.489
	Clam	BS S50	6.483 5.850	0.990 1.761	6 6	*t*-test (log-transformed data)	4.50
	Fish	BS S50	† 1.392 0.700	1.072 0.135	6 4	*t*-test (log-transformed data)	3.10
	All	BS S50	† 3.025 † 2.703	0.750 0.889	18 16	Wilcoxon Rank-Sum test	2.35
PCB 18 (ng/g wet wt.)	Mussel	BS S50	1.667 * † 0.808	0.088 0.177	6 6	*t*-test	0.441
	Clam	BS S50	† 0.517 † 0.333	0.157 0.186	6 6	*t*-test	0.544
	Fish	BS S50	† 0.692 1.000	0.134 0.308	6 4	*t*-test	0.683
	All	BS S50	† 0.958 † 0.678	0.141 0.135	18 16	*t*-test	0.401
PCB 19 (ng/g wet wt.)	Mussel	BS S50	† 0.375 † 0.158	0.148 0.108	6 6	Wilcoxon Rank-Sum test	0.408
	Clam	BS S50	† 1.558 † 2.175	0.707 0.680	6 6	*t*-test	2.19
	Fish	BS S50	† 0.808 † 0.313	0.758 0.263	6 4	Wilcoxon Rank-Sum test	2.24
	All	BS S50	† 0.914 † 0.953	0.349 0.350	18 16	Wilcoxon Rank-Sum test	1.01

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Table A16 (Continued)							
Contaminant	Organ-ism	Treat-ment	Mean Concen-tration	Standard Error	N	Test Used for Statisti-cal Comparisons	LSD d_{min}[1]
PCB 22 (ng/g wet wt.)	Mussel	BS S50	4.050 4.350	0.274 0.430	6 6	*t*-test	1.14
	Clam	BS S50	8.850 7.317	0.988 0.804	6 6	*t*-test	2.84
	Fish	BS S50	† 1.242 † 1.963	0.356 0.699	6 4	*t*-test	1.64
	All	BS S50	† 4.714 † 4.866	0.834 0.652	18 16	*t*-test	2.20
PCB 25 (ng/g wet wt.)	Mussel	BS S50	6.383 5.250	0.755 0.678	6 6	*t*-test	2.26
	Clam	BS S50	3.200 * † 1.625	0.306 0.353	6 6	*t*-test	1.04
	Fish	BS S50	† 0.800 † 2.025	0.475 1.226	6 4	*t*-test	2.62
	All	BS S50	† 3.461 † 3.084	0.628 0.581	18 16	*t*-test	1.76
PCB 26 (ng/g wet wt.)	Mussel	BS S50	† 1.917 * †† 0.200	0.562 0	6 6	Wilcoxon Rank-Sum test	1.25
	Clam	BS S50	† 0.933 † 0.933	0.633 0.633	6 6	Wilcoxon Rank-Sum test	2.00
	Fish	BS S50	† 1.217 † 3.500	0.580 1.083	6 4	*t*-test	2.59
	All	BS S50	† 1.356 † 1.300	0.337 0.472	18 16	Wilcoxon Rank-Sum test	1.16
PCB 29 (ng/g wet wt.)	Mussel	BS S50	†† 0.050 † 0.175	0 0.125	6 6	Wilcoxon Rank-Sum test	0.279
	Clam	BS S50	†† 0.050 † 0.442	0 0.180	6 6	*t*-test	0.400
	Fish	BS S50	† 0.725 † 0.163	0.675 0.113	6 4	Wilcoxon Rank-Sum test	1.96
	All	BS S50	† 0.275 † 0.272	0.225 0.088	18 16	Wilcoxon Rank-Sum test	0.515
PCB 31+28 (ng/g wet wt.)	Clam	BS S50	9.633 * 5.667	1.084 1.058	6 6	*t*-test	3.37
	Fish	BS S50	† 4.683 7.250 *	0.939 0.459	6 4	Wilcoxon Rank-Sum test	2.83
	All	BS S50	† 7.158 6.300	1.012 0.684	12 10	*t*-test	2.66

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Table A16 (Continued)							
Contaminant	Organ-ism	Treat-ment	Mean Concen-tration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 32+16 (ng/g wet wt.)	Mussel	BS S50	3.317 * † 2.150	0.244 0.407	6 6	*t*-test	1.06
	Clam	BS S50	† 1.750 † 1.300	0.649 0.635	6 6	Wilcoxon Rank-Sum test	2.02
	Fish	BS S50	† 3.100 † 1.025	2.800 0.725	6 4	Wilcoxon Rank-Sum test	8.18
	All	BS S50	† 2.722 † 1.550	0.919 0.335	18 16	Wilcoxon Rank-Sum test	2.09
PCB 33+53 (ng/g wet wt.)	Fish	BS S50	5.450 9.675	1.822 2.374	6 4	*t*-test	6.81
	All	BS S50	† 2.053 † 2.727	0.871 1.255	17 15	Wilcoxon Rank-Sum test	3.06
PCB 40 (ng/g wet wt.)	Mussel	BS S50	2.717 * † 1.317	0.204 0.281	6 6	*t*-test	0.774
	Clam	BS S50	† 0.775 * † 0.192	0.150 0.142	6 6	*t*-test	0.460
	Fish	BS S50	† 0.675 † 0.213	0.625 0.163	6 4	Wilcoxon Rank-Sum test	1.83
	All	BS S50	† 1.389 † 0.619	0.311 0.182	18 16	Wilcoxon Rank-Sum test	0.758
PCB 42+37 (ng/g wet wt.)	Mussel	BS S50	† 1.283 † 0.817	0.263 0.337	6 6	*t*-test	0.952
	Clam	BS S50	0.967 † 0.400	0.095 0.227	6 6	Wilcoxon Rank-Sum test	0.549
	Fish	BS S50	† 0.500 † 0.375	0.400 0.275	6 4	Wilcoxon Rank-Sum test	1.26
	All	BS S50	† 0.917 † 0.550	0.172 0.165	18 16	Wilcoxon Rank-Sum test	0.488
PCB 44 (ng/g wet wt.)	Mussel	BS S50	3.000 3.167	0.482 0.274	6 6	*t*-test	1.24
	Clam	BS S50	† 2.433 † 1.300	0.540 0.573	6 6	*t*-test	1.75
	Fish	BS S50	† 0.600 †† 0.200	0.400 0	6 4	Wilcoxon Rank-Sum test	1.15
	All	BS S50	† 2.011 † 1.725	0.359 0.382	18 16	Wilcoxon Rank-Sum test	1.07

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Table A16 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min} [1]
PCB 45 (ng/g wet wt.)	Mussel	BS S50	2.583 † 2.117	0.070 0.384	6 6	Wilcoxon Rank-Sum test	0.870
	Clam	BS S50	4.783 3.933	0.778 0.300	6 6	*t*-test	1.86
	Fish	BS S50	† 1.200 3.350 *	0.448 0.210	6 4	*t*-test	1.35
	All	BS S50	† 2.856 † 3.106	0.456 0.273	18 16	Wilcoxon Rank-Sum test	1.12
PCB 46 (ng/g wet wt.)	Mussel	BS S50	†† 0.050 † 0.208	0 0.158	6 6	Wilcoxon Rank-Sum test	0.353
	Clam	BS S50	†† 0.050 † 4.375	0 2.520	6 6	Wilcoxon Rank-Sum test	5.62
	All	BS S50	†† 0.050 † 2.292 *	0 1.358	13 12	Wilcoxon Rank-Sum test	2.69
PCB 48+47 (ng/g wet wt.)	Mussel	BS S50	† 1.683 † 0.467	0.646 0.265	6 6	*t*-test	1.56
	All	BS S50	† 1.275 † 0.407	0.543 0.233	8 7	Wilcoxon Rank-Sum test	1.34
PCB 49+43 (ng/g wet wt.)	Mussel	BS S50	3.433 3.850	0.391 0.186	6 6	*t*-test	0.965
	Clam	BS S50	3.183 2.967	0.196 0.117	6 6	*t*-test	0.508
	Fish	BS S50	2.650 5.325 *	0.449 0.887	6 4	*t*-test	2.07
	All	BS S50	3.089 3.888	0.212 0.318	18 16	Wilcoxon Rank-Sum test	0.762
PCB 56+60 (ng/g wet wt.)	Mussel	BS S50	1.867 2.700 *	0.265 0.252	6 6	*t*-test	0.815
	Clam	BS S50	2.000 † 1.242	0.421 0.295	6 6	*t*-test	1.15
	Fish	BS S50	† 0.325 † 0.238	0.275 0.188	6 4	Wilcoxon Rank-Sum test	0.863
	All	BS S50	† 1.397 † 1.538	0.256 0.291	18 16	*t*-test	0.787

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Table A16 (Continued)

Contaminant	Organ-ism	Treat-ment	Mean Concen-tration	Standard Error	N	Test Used for Statisti-cal Comparisons	LSD d_{min}[1]
PCB 63 (ng/g wet wt.)	Mussel	BS S50	5.033 * 2.450	0.301 0.226	6 6	*t*-test	0.839
	Clam	BS S50	2.250 1.550	0.338 0.161	6 6	*t*-test	0.833
	Fish	BS S50	† 3.800 † 3.750	0.861 2.109	5 4	*t*-test	4.58
	All	BS S50	† 3.694 † 2.438	0.411 0.530	18 16	*t*-test	1.35
PCB 64+41+71 (ng/g wet wt.)	Fish	BS S50	† 1.000 † 2.925	0.700 0.909	6 4	*t*-test	2.61
	All	BS S50	† 0.825 † 1.245	0.525 0.501	8 11	Wilcoxon Rank-Sum test	1.56
PCB 70+76 (ng/g wet wt.)	Mussel	BS S50	† 2.917 4.883 *	0.570 0.285	6 6	Wilcoxon Rank-Sum test	1.42
	Clam	BS S50	4.017 3.367	0.320 0.223	6 6	*t*-test	0.869
	Fish	BS S50	† 0.567 †† 0.200	0.367 0	6 4	Wilcoxon Rank-Sum test	1.06
	All	BS S50	† 2.500 † 3.144	0.421 0.488	18 16	Wilcoxon Rank-Sum test	1.30
PCB 74 (ng/g wet wt.)	Mussel	BS S50	1.433 1.500	0.117 0.097	6 6	*t*-test	0.339
	Clam	BS S50	0.917 0.783	0.054 0.091	6 6	*t*-test	0.236
	Fish	BS S50	† 0.625 0.975	0.125 0.144	6 4	*t*-test	0.445
	All	BS S50	† 0.992 1.100	0.099 0.100	18 16	*t*-test	0.287
PCB 82 (ng/g wet wt.)	Mussel	BS S50	† 0.925 1.367 *	0.179 0.092	6 6	Wilcoxon Rank-Sum test	0.448
	Clam	BS S50	21.800 18.100	6.345 3.417	6 6	*t*-test	16.1
	Fish	BS S50	† 0.542 † 0.400	0.492 0.226	6 4	Wilcoxon Rank-Sum test	1.48
	All	BS S50	† 7.756 † 7.400	3.127 2.460	18 16	*t*-test (log-transformed data)	8.25

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Table A16 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 83 (ng/g wet wt.)	Mussel	BS S50	† 0.908 1.517	0.206 0.289	6 6	*t*-test	0.791
	Clam	BS S50	† 0.658 † 0.600	0.140 0.219	6 6	*t*-test	0.579
	Fish	BS S50	† 0.642 1.100	0.131 0.208	6 4	*t*-test	0.535
	All	BS S50	† 0.736 † 1.069	0.093 0.171	18 16	*t*-test	0.384
PCB 85 (ng/g wet wt.)	Mussel	BS S50	4.567 6.100 *	0.425 0.375	6 6	*t*-test	1.26
	Clam	BS S50	† 2.567 2.633	0.551 0.169	6 6	*t*-test	1.28
	Fish	BS S50	6.800 7.900	0.208 1.163	6 4	*t*-test	2.20
	All	BS S50	† 4.644 5.250	0.477 0.628	18 16	*t*-test	1.59
PCB 87 (ng/g wet wt.)	Mussel	BS S50	2.000 2.917 *	0.261 0.158	6 6	*t*-test	0.679
	Clam	BS S50	† 1.242 1.383	0.272 0.135	6 6	*t*-test	0.676
	Fish	BS S50	† 0.892 1.500	0.193 0.212	6 4	*t*-test	0.679
	All	BS S50	† 1.378 1.988 *	0.174 0.206	18 16	*t*-test	0.545
PCB 91 (ng/g wet wt.)	Mussel	BS S50	2.183 2.383	0.218 0.298	6 6	*t*-test	0.823
	Clam	BS S50	†† 0.050 † 0.250	0 0.142	6 6	Wilcoxon Rank-Sum test	0.316
	Fish	BS S50	† 0.158 † 0.488	0.108 0.159	6 4	*t*-test	0.426
	All	BS S50	† 0.797 † 1.109	0.250 0.284	18 16	Wilcoxon Rank-Sum test	0.767

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Table A16 (Continued)							
Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 92+84 (ng/g wet wt.)	Mussel	BS S50	2.567 2.800	0.486 0.369	6 6	Wilcoxon Rank-Sum test	1.36
	Clam	BS S50	† 0.608 † 0.508	0.287 0.227	6 6	Wilcoxon Rank-Sum test	0.816
	Fish	BS S50	† 0.858 † 0.988	0.196 0.403	6 4	*t*-test	0.927
	All	BS S50	† 1.344 † 1.488	0.282 0.321	18 16	Wilcoxon Rank-Sum test	0.866
PCB 95+66 (ng/g wet wt.)	Fish	BS S50	† 4.033 11.650 *	1.130 1.735	6 4	*t*-test	4.54
PCB 97 (ng/g wet wt.)	Mussel	BS S50	1.283 1.417	0.182 0.070	6 6	Wilcoxon Rank-Sum test	0.434
	Fish	BS S50	† 0.283 † 0.988	0.161 0.399	6 4	*t*-test	0.863
	All	BS S50	† 0.783 † 1.245	0.190 0.167	12 10	*t*-test	0.539
PCB 99 (ng/g wet wt.)	Mussel	BS S50	1.983 2.550	0.281 0.134	6 6	*t*-test	0.693
	Clam	BS S50	1.400 1.250	0.148 0.134	6 6	*t*-test	0.445
	Fish	BS S50	† 0.775 1.525 *	0.161 0.132	6 4	*t*-test	0.523
	All	BS S50	† 1.386 1.806	0.164 0.168	18 16	*t*-test	0.479
PCB 100 (ng/g wet wt.)	Clam	BS S50	0.900 † 0.558	0.093 0.241	6 6	*t*-test	0.575
	Fish	BS S50	† 0.283 †† 0.050	0.161 0	6 4	Wilcoxon Rank-Sum test	0.464
	All	BS S50	† 0.411 † 0.241	0.105 0.106	18 16	Wilcoxon Rank-Sum test	0.305
PCB 101+89 (ng/g wet wt.)	Mussel	BS S50	5.617 6.683	0.694 0.350	6 6	*t*-test	1.73
	Clam	BS S50	4.967 4.667	0.510 0.332	6 6	*t*-test	1.36
	Fish	BS S50	2.450 3.575	0.362 0.384	6 4	*t*-test	1.26
	All	BS S50	4.344 5.150	0.442 0.377	18 16	*t*-test	1.20
(Sheet 12 of 19)							

Table A16 (Continued)							
Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 107 (ng/g wet wt.)	Mussel	BS S50	† 0.542 † 0.433	0.107 0.122	6 6	Wilcoxon Rank-Sum test	0.362
	Clam	BS S50	† 0.142 †† 0.050	0.092 0	6 6	Wilcoxon Rank-Sum test	0.204
	Fish	BS S50	† 0.283 † 0.425	0.148 0.217	6 4	Wilcoxon Rank-Sum test	0.582
	All	BS S50	† 0.322 † 0.288	0.076 0.080	18 16	Wilcoxon Rank-Sum test	0.225
PCB 110+77 (ng/g wet wt.)	Mussel	BS S50	7.917 11.400 *	1.057 0.585	6 6	*t*-test	2.69
	Clam	BS S50	7.517 7.350	0.720 0.578	6 6	*t*-test	2.06
	Fish	BS S50	2.750 4.650 *	0.422 0.380	6 4	*t*-test	1.40
	All	BS S50	6.061 8.194 *	0.708 0.759	18 16	*t*-test	2.11
PCB 118 (ng/g wet wt.)	Mussel	BS S50	4.600 6.333 *	0.553 0.356	6 6	*t*-test	1.46
	Clam	BS S50	3.183 3.267	0.345 0.318	6 6	*t*-test	1.05
	Fish	BS S50	1.883 2.950 *	0.241 0.150	6 4	*t*-test	0.748
	All	BS S50	3.222 4.338 *	0.346 0.436	18 16	*t*-test (log-transformed data)	1.12
PCB 128 (ng/g wet wt.)	Mussel	BS S50	1.200 1.067	0.097 0.042	6 6	*t*-test	0.235
	Clam	BS S50	† 0.692 † 0.433	0.146 0.125	6 6	*t*-test	0.429
	All	BS S50	† 0.647 † 0.575	0.127 0.115	18 16	Wilcoxon Rank-Sum test	0.352
PCB 131 (ng/g wet wt.)	Mussel	BS S50	† 0.342 1.100 *	0.136 0.235	6 6	*t*-test	0.606
	Clam	BS S50	†† 0.050 † 0.125	0 0.075	6 6	Wilcoxon Rank-Sum test	0.167
	All	BS S50	† 0.147 † 0.472	0.054 0.153	18 16	Wilcoxon Rank-Sum test	0.316

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Table A16 (Continued)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 134+114 (ng/g wet wt.)	Mussel	BS S50	3.867 7.567 *	0.739 1.006	6 6	*t*-test	2.78
	Clam	BS S50	2.150 1.783	0.423 0.382	6 6	*t*-test	1.27
	Fish	BS S50	0.917 2.700 *	0.070 0.970	6 4	*t*-test (log-transformed data)	1.78
	All	BS S50	2.311 4.181	0.397 0.812	18 16	*t*-test	1.78
PCB 135+144 (ng/g wet wt.)	Mussel	BS S50	† 0.550 † 0.867	0.350 0.422	6 6	Wilcoxon Rank-Sum test	1.22
	Fish	BS S50	† 1.417 5.300 *	0.586 1.529	6 4	*t*-test	3.26
	All	BS S50	† 0.827 † 2.077	0.290 0.778	15 13	Wilcoxon Rank-Sum test	1.62
PCB 136 (ng/g wet wt.)	Mussel	BS S50	4.850 † 5.175	0.966 1.144	6 6	Wilcoxon Rank-Sum test	3.34
	Fish	BS S50	† 0.242 †† 0.050	0.192 0	6 4	Wilcoxon Rank-Sum test	0.553
	All	BS S50	† 1.714 † 1.972	0.620 0.758	18 16	Wilcoxon Rank-Sum test	1.98
PCB 137+176 (ng/g wet wt.)	Mussel	BS S50	2.000 2.317	0.100 0.125	6 6	*t*-test (log-transformed data)	0.357
	All	BS S50	† 0.700 † 0.900	0.225 0.287	18 16	Wilcoxon Rank-Sum test	0.735
PCB 141 (ng/g wet wt.)	Clam	BS S50	3.233 * 2.267	0.361 0.133	6 6	*t*-test	0.858
	Fish	BS S50	† 2.683 4.325 *	0.511 0.382	6 4	Wilcoxon Rank-Sum test	1.63
	All	BS S50	† 2.072 † 2.044	0.366 0.417	18 16	Wilcoxon Rank-Sum test	1.12
PCB 146 (ng/g wet wt.)	Mussel	BS S50	†† 0.400 † 2.583	0 0.979	6 6	Wilcoxon Rank-Sum test	2.18
	Clam	BS S50	2.983 2.533	0.101 0.178	6 6	*t*-test	0.457
	Fish	BS S50	† 2.950 † 3.500	0.567 1.162	6 4	Wilcoxon Rank-Sum test	2.68
	All	BS S50	† 2.111 † 2.794	0.345 0.450	18 16	*t*-test	1.14

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Table A16 (Continued)							
Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min} [1]
PCB 149 (ng/g wet wt.)	Mussel	BS S50	6.117 5.617	0.858 0.506	6 6	*t*-test	2.22
	Clam	BS S50	3.283 2.600	0.440 0.171	6 6	*t*-test	1.05
	Fish	BS S50	† 1.592 1.825	0.320 0.132	6 4	Wilcoxon Rank-Sum test	0.953
	All	BS S50	† 3.664 3.538	0.553 0.464	18 16	Wilcoxon Rank-Sum test	1.49
PCB 151 (ng/g wet wt.)	Mussel	BS S50	1.583 1.233	0.215 0.088	6 6	*t*-test	0.518
	Clam	BS S50	1.167 0.800	0.163 0.097	6 6	*t*-test	0.422
	Fish	BS S50	0.633 † 0.350	0.056 0.184	6 4	*t*-test	0.372
	All	BS S50	1.128 † 0.850	0.128 0.108	18 16	*t*-test	0.346
PCB 153+ 132+105 (ng/g wet wt.)	Mussel	BS S50	15.617 12.217	2.016 0.914	6 6	*t*-test	4.93
	Clam	BS S50	9.867 8.417	1.948 1.775	6 6	*t*-test (log-transformed data)	5.87
	Fish	BS S50	3.867 5.600	0.228 0.974	6 4	*t*-test	1.89
	All	BS S50	9.783 9.138	1.459 1.002	18 16	*t*-test	3.70
PCB 157+200 (ng/g wet wt.)	Mussel	BS S50	† 0.558 0.750	0.116 0.173	6 6	*t*-test	0.463
	Clam	BS S50	†† 0.050 † 0.142	0 0.092	6 6	Wilcoxon Rank-Sum test	0.204
	Fish	BS S50	† 0.250 † 0.400	0.132 0.211	6 4	Wilcoxon Rank-Sum test	0.542
	All	BS S50	† 0.286 † 0.434	0.075 0.108	18 16	Wilcoxon Rank-Sum test	0.263

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Table A16 (Continued)							
Contaminant	**Organ-ism**	**Treat-ment**	**Mean Concen-tration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**LSD d_{min}[1]**
PCB 158 (ng/g wet wt.)	Mussel	BS S50	1.500 2.333	0.177 0.481	6 6	*t*-test	1.14
	Clam	BS S50	† 0.500 †† 0.100	0.254 0	6 6	Wilcoxon Rank-Sum test	0.567
	Fish	BS S50	† 0.142 † 0.313	0.092 0.263	6 4	Wilcoxon Rank-Sum test	0.547
	All	BS S50	† 0.714 † 0.991	0.172 0.324	18 16	Wilcoxon Rank-Sum test	0.724
PCB 163+138 (ng/g wet wt.)	Mussel	BS S50	8.483 9.367	1.011 0.499	6 6	*t*-test	2.51
	Clam	BS S50	6.267 5.400	0.533 0.576	6 6	*t*-test	1.75
	Fish	BS S50	2.967 3.400	0.201 0.248	6 4	*t*-test	0.736
	All	BS S50	5.906 6.388	0.659 0.686	18 16	*t*-test	1.94
PCB 170+190 (ng/g wet wt.)	Mussel	BS S50	3.533 5.967 *	0.350 0.433	6 6	*t*-test	1.24
	Clam	BS S50	7.433 6.900	0.674 0.374	6 6	*t*-test	1.72
	Fish	BS S50	† 0.808 1.150	0.181 0.087	6 4	*t*-test	0.545
	All	BS S50	† 3.925 5.113	0.703 0.633	18 16	*t*-test	1.95
PCB 172+197 (ng/g wet wt.)	Mussel	BS S50	† 0.288 †† 0.050	0.160 0	6 6	Wilcoxon Rank-Sum test	0.356
	Clam	BS S50	† 0.158 † 0.233	0.108 0.139	6 6	Wilcoxon Rank-Sum test	0.393
	Fish	BS S50	† 0.192 † 0.188	0.142 0.138	6 4	Wilcoxon Rank-Sum test	0.479
	All	BS S50	† 0.213 † 0.153	0.076 0.062	18 16	Wilcoxon Rank-Sum test	0.203
PCB 173 (ng/g wet wt.)	Mussel	BS S50	7.067 † 6.442	0.920 1.365	6 6	*t*-test	3.67
	Fish	BS S50	† 0.142 † 0.188	0.092 0.138	6 4	Wilcoxon Rank-Sum test	0.364
	All	BS S50	† 2.419 † 2.481	0.848 0.928	18 16	Wilcoxon Rank-Sum test	2.56

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Table A16 (Continued)							
Contaminant	Organ-ism	Treat-ment	Mean Concen-tration	Standard Error	N	Test Used for Statisti-cal Comparisons	LSD d_{min}[1]
PCB 175 (ng/g wet wt.)	Mussel	BS S50	† 0.217 †† 0.050	0.106 0	6 6	Wilcoxon Rank-Sum test	0.237
	Clam	BS S50	† 0.250 † 0.217	0.127 0.106	6 6	Wilcoxon Rank-Sum test	0.369
	All	BS S50	† 0.172 † 0.113	0.056 0.043	18 16	Wilcoxon Rank-Sum test	0.147
PCB 177 (ng/g wet wt.)	Mussel	BS S50	2.917 3.233	0.665 0.272	6 6	*t*-test	1.60
	Clam	BS S50	1.350 * 0.800	0.131 0.086	6 6	*t*-test	0.349
	All	BS S50	† 1.439 † 1.525	0.355 0.364	18 16	Wilcoxon Rank-Sum test	1.04
PCB 178 (ng/g wet wt.)	Mussel	BS S50	†† 0.050 † 33.258 *	0 7.575	6 6	Wilcoxon Rank-Sum test	16.9
	Fish	BS S50	†† 0.100 † 0.600	0 0.500	6 4	Wilcoxon Rank-Sum test	0.912
	All	BS S50	†† 0.083 † 12.659 *	0.006 4.915	18 16	Wilcoxon Rank-Sum test	9.42
PCB 180 (ng/g wet wt.)	Mussel	BS S50	† 1.600 † 1.317	0.445 0.510	6 6	Wilcoxon Rank-Sum test	1.51
	Clam	BS S50	† 1.267 †† 0.200	0.479 0	6 6	Wilcoxon Rank-Sum test	1.07
	All	BS S50	† 1.022 † 0.619	0.251 0.228	18 16	Wilcoxon Rank-Sum test	0.697
PCB 183 (ng/g wet wt.)	Mussel	BS S50	1.283 0.883	0.192 0.054	6 6	Wilcoxon Rank-Sum test	0.445
	Clam	BS S50	† 0.450 * † 0.092	0.128 0.042	6 6	*t*-test (log-transformed data)	0.300
	Fish	BS S50	† 0.142 †† 0.050	0.092 0	6 4	Wilcoxon Rank-Sum test	0.264
	All	BS S50	† 0.625 † 0.378	0.140 0.104	18 16	Wilcoxon Rank-Sum test	0.364
PCB 185 (ng/g wet wt.)	Fish	BS S50	† 0.192 †† 0.050	0.142 0	6 4	Wilcoxon Rank-Sum test	0.408
	All	BS S50	† 0.097 †† 0.050	0.047 0	18 16	Wilcoxon Rank-Sum test	0.102

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Table A16 (Continued)							
Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 187+182 (ng/g wet wt.)	Mussel	BS S50	2.083 1.917	0.206 0.075	6 6	*t*-test	0.488
	Clam	BS S50	1.183 * 0.783	0.147 0.095	6 6	*t*-test	0.390
	Fish	BS S50	† 0.142 †† 0.050	0.092 0	6 4	Wilcoxon Rank-Sum test	0.264
	All	BS S50	† 1.136 † 1.025	0.210 0.197	18 16	Wilcoxon Rank-Sum test	0.592
PCB 191 (ng/g wet wt.)	Clam	BS S50	†† 0.050 † 0.108	0 0.058	6 6	Wilcoxon Rank-Sum test	0.130
	Fish	BS S50	† 0.375 †† 0.050	0.325 0	6 4	Wilcoxon Rank-Sum test	0.937
	All	BS S50	† 0.158 † 0.072	0.108 0.022	18 16	Wilcoxon Rank-Sum test	0.238
PCB 193 (ng/g wet wt.)	Fish	BS S50	† 0.175 †† 0.050	0.125 0	6 4	Wilcoxon Rank-Sum test	0.360
	All	BS S50	† 0.092 †† 0.050	0.042 0	18 16	Wilcoxon Rank-Sum test	0.090
PCB 194 (ng/g wet wt.)	Mussel	BS S50	†† 0.050 † 0.158	0 0.108	6 6	Wilcoxon Rank-Sum test	0.241
	Clam	BS S50	† 0.758 † 0.433	0.157 0.128	6 6	*t*-test	0.451
	All	BS S50	† 0.286 † 0.234	0.095 0.072	18 16	Wilcoxon Rank-Sum test	0.247
PCB 198 (ng/g wet wt.)	Mussel	BS S50	0.983 0.900	0.122 0.103	6 6	*t*-test	0.357
	Clam	BS S50	† 0.600 † 0.217	0.211 0.106	6 6	*t*-test	0.526
	Fish	BS S50	† 0.142 †† 0.050	0.092 0	6 4	Wilcoxon Rank-Sum test	0.264
	All	BS S50	† 0.575 † 0.431	0.117 0.109	18 16	Wilcoxon Rank-Sum test	0.327
PCB 201 (ng/g wet wt.)	Clam	BS S50	† 0.217 †† 0.050	0.106 0	6 6	Wilcoxon Rank-Sum test	0.237
	All	BS S50	† 0.106 †† 0.050	0.038 0	18 16	Wilcoxon Rank-Sum test	0.083

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Table A16 (Concluded)

Contaminant	Organism	Treatment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
PCB 202+171 (ng/g wet wt.)	Mussel	BS S50	1.300 0.900	0.155 0.167	6 6	*t*-test	0.508
	Clam	BS S50	1.083 † 0.775	0.117 0.153	6 6	*t*-test	0.428
	Fish	BS S50	†† 0.050 † 0.263	0 0.213	6 4	Wilcoxon Rank-Sum test	0.387
	All	BS S50	† 0.811 † 0.694	0.146 0.114	18 16	Wilcoxon Rank-Sum test	0.383
PCB 203+196 (ng/g wet wt.)	Clam	BS S50	†† 0.050 † 0.400	0 0.227	6 6	Wilcoxon Rank-Sum test	0.507
	All	BS S50	†† 0.050 † 0.181	0 0.092	18 16	Wilcoxon Rank-Sum test	0.175
PCB 205 (ng/g wet wt.)	Clam	BS S50	†† 0.050 † 0.092	0 0.042	6 6	Wilcoxon Rank-Sum test	0.093
	All	BS S50	†† 0.050 † 0.656	0 0.016	18 16	Wilcoxon Rank-Sum test	0.030
PCB 207 (ng/g wet wt.)	Clam	BS S50	†† 0.050 † 0.108	0 0.058	6 6	Wilcoxon Rank-Sum test	0.130
	All	BS S50	†† 0.050 † 0.072	0 0.022	18 16	Wilcoxon Rank-Sum test	0.042
PCB 208+195 (ng/g wet wt.)	Clam	BS S50	† 0.408 † 0.175	0.188 0.125	6 6	Wilcoxon Rank-Sum test	0.502
	Fish	BS S50	†† 0.050 † 0.863	0 0.813	6 4	Wilcoxon Rank-Sum test	1.48
	All	BS S50	† 0.169 † 0.300	0.072 0.205	18 16	Wilcoxon Rank-Sum test	0.423
Lipid (percent wet wt.)	Mussel	BS S50	1.496 1.636	0.108 0.073	6 6	*t*-test	0.290
	Clam	BS S50	2.994 3.075	0.606 0.493	6 6	*t*-test	1.74
	Fish	BS S50	1.184 1.384	0.060 0.153	6 4	*t*-test (log-transformed data)	0.328
	All	BS S50	1.891 2.112	0.272 0.264	18 16	Wilcoxon Rank-Sum test	0.777

Table A17.
Descriptive Statistics and Statistical Comparisons of Contaminant Bioaccumulation and Lipid in Organisms Exposed to Oakland Inner, Outer, and Hot Sediments and Berkeley Flats Reference Sediment for 28 Days

Contaminant	Organism	Sediment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
Acenaphthene (ng/g wet wt.)	Mussel	Hot Reference	6.833 A[2] † 1.209[3] B	0.493 0.413	12 12	Nonparametric LSD test (data converted to rankits)	1.05
	Clam	Hot Reference	† 46.383 A † 1.025 B	7.429 0.380	12 12	LSD test (log-transformed data)	15.5
	Fish	Hot Reference	†† 1.468 A † 0.922 A	0.295 0.385	10 12	Nonparametric LSD test (data converted to rankits)	1.07
Acenaphthylene (ng/g wet wt.)	Mussel	Hot Reference	8.623 A †† 0.148 B	0.853 0.021	12 12	LSD test (log-transformed data)	1.42
	Clam	Hot Reference	† 0.409 A † 0.213 A	0.213 0.046	12 12	Nonparametric LSD test (data converted to rankits)	0.39
Anthracene (ng/g wet wt.)	Mussel	Hot Reference	28.125 A † 1.686 B	4.467 0.758	12 12	LSD test (log-transformed data)	6.76
	Clam	Hot Reference	226.242 A † 0.571 B	22.272 0.114	12 12	*t*-test for unequal variances	47.2
	Fish	Hot Reference	† 1.900 A †† 0.147 B	0.900 0.011	10 12	Nonparametric LSD test (data converted to rankits)	1.73
Benz[a]anthracene (ng/g wet wt.)	Mussel	Hot Reference	414.583 A † 1.341 B	65.429 0.417	12 12	LSD test (log-transformed data)	102
	Clam	Hot Reference	471.667 A 4.597 B	23.709 0.413	12 12	LSD test (log-transformed data)	49.7
	Fish	Hot Reference	† 7.493 A † 0.303 B	4.352 0.097	10 12	Nonparametric LSD test (data converted to rankits)	8.33
Benzo[a]pyrene (ng/g wet wt.)	Mussel	Hot Reference	425.000 A † 0.394 B	62.682 0.119	12 12	LSD test (log-transformed data)	102
	Clam	Hot Reference	349.250 A 4.869 B	21.974 0.298	12 12	LSD test (log-transformed data)	44.8
	Fish	Hot Reference	† 3.425 A † 0.158 B	2.054 0.067	10 12	Nonparametric LSD test (data converted to rankits)	3.97

[1] Minimum significant difference that can be detected by LSD test on untransformed data.
[2] For a given contaminant, means followed by the same letter are not significantly different from each other (two-tailed test, $\alpha/2 = 0.025$).
[3] † Mean includes at least one concentration less than DL and set equal to DL/10;
†† All concentrations less than DL and set equal to DL/10. Comparisons in which all observations for an organism were less than DL are not included in the table.

(Sheet 1 of 6)

Table A17 (Continued)

Contaminant	Organism	Sediment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min} [1]
Benzo[b]fluoranthene (ng/g wet wt.)	Mussel	Hot Reference	629.167 A † 2.568 B	81.111 0.565	12 12	*t*-test for unequal variances	133
	Clam	Hot Reference	456.417 A 8.692 B	27.764 0.654	12 12	LSD test (log-transformed data)	57.2
	Fish	Hot Reference	† 7.430 A †† 0.098 B	4.527 0.008	10 12	Nonparametric LSD test (data converted to rankits)	8.73
Benzo[k]fluoranthene (ng/g wet wt.)	Mussel	Hot Reference	289.917 A † 0.424 B	38.720 0.119	12 12	LSD test (log-transformed data)	63.1
	Clam	Hot Reference	217.417 A † 2.166 B	14.430 0.629	12 12	*t*-test for unequal variances	30.2
	Fish	Hot Reference	† 5.225 A †† 0.097 B	3.365 0.008	10 12	Nonparametric LSD test (data converted to rankits)	6.56
Benzo[g,h,i]perylene (ng/g wet wt.)	Mussel	Hot Reference	123.575 A † 0.633 B	16.067 0.347	12 12	*t*-test for unequal variances	26.3
	Clam	Hot Reference	108.525 A 5.224 B	8.212 0.372	12 12	LSD test (log-transformed data)	17.0
	Fish	Hot Reference	† 0.572 A † 0.154 B	0.295 0.057	10 12	Nonparametric LSD test (data converted to rankits)	0.59
Chrysene (ng/g wet wt.)	Mussel	Hot Reference	642.750 A † 3.845 B	88.892 0.658	12 12	LSD test (log-transformed data)	139
	Clam	Hot Reference	663.250 A 4.757 B	33.823 0.291	12 12	LSD test (log-transformed data)	70.3
	Fish	Hot Reference	† 5.686 A †† 0.101 B	3.439 0.008	10 12	Nonparametric LSD test (data converted to rankits)	6.67
Dibenz[a,h]anthracene (ng/g wet wt.)	Mussel	Hot Reference	14.468 A †† 0.489 B	2.123 0.059	12 12	LSD test (log-transformed data)	4.40
	Clam	Hot Reference	25.683 A † 0.619 B	1.761 0.201	12 12	*t*-test for unequal variances	3.75
Dibenzothiophene (ng/g wet wt.)	Mussel	Hot Reference	6.038 A † 2.603 B	0.967 1.728	12 12	Nonparametric LSD test (data converted to rankits)	3.53
Dibenzothiophene (continued)	Clam	Hot Reference	42.933 A † 0.373 B	4.521 0.063	12 12	LSD test (log-transformed data)	9.62

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Table A17 (Continued)

Contaminant	Organism	Sediment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
Fluoranthene (ng/g wet wt.)	Mussel	Hot Reference	692.917 A 8.198 B	117.360 0.785	12 12	*t*-test for unequal variances	179
	Clam	Hot Reference	1827.92 A 10.97 B	102.391 0.837	12 12	LSD test (log-transformed data)	217
	Fish	Hot Reference	† 12.807 A †† 0.114 B	7.547 0.009	10 12	Nonparametric LSD test (data converted to rankits)	14.7
Fluorene (ng/g wet wt.)	Mussel	Hot Reference	5.673 A † 2.771 B	0.376 0.759	12 12	*t*-test for unequal variances (log-transformed data)	1.65
	Clam	Hot Reference	† 28.598 A † 3.639 B	3.542 0.969	12 12	*t*-test for unequal variances	7.43
	Fish	Hot Reference	†† 1.393 A † 1.080 A	0.277 0.430	10 12	*t*-test for unequal variances (log-transformed data)	1.15
Indeno[1,2,3-cd]pyrene (ng/g wet wt.)	Mussel	Hot Reference	93.775 A † 0.425 B	13.997 0.117	12 12	LSD test (log-transformed data)	22.9
	Clam	Hot Reference	78.600 A 4.186 B	6.180 0.253	12 12	LSD test (log-transformed data)	12.8
	Fish	Hot Reference	† 1.112 A †† 0.090 B	0.353 0.008	10 12	*t*-test for unequal variances (log-transformed data)	0.69
Naphthalene (ng/g wet wt.)	Mussel	Hot Reference	58.233 A 46.433 B	1.690 3.098	12 12	LSD test	7.42
	Clam	Hot Reference	59.742 A 26.982 B	3.603 6.377	12 12	*t*-test for unequal variances	13.1
	Fish	Hot Reference	64.350 A † 16.653 B	6.309 2.493	10 12	*t*-test for unequal variances	12.9
Phenanthrene (ng/g wet wt.)	Mussel	Hot Reference	93.558 A 27.792 B	13.896 1.438	12 12	*t*-test for unequal variances	20.8
	Clam	Hot Reference	622.167 A 14.519 B	63.863 3.059	12 12	*t*-test for unequal variances (log-transformed data)	136
	Fish	Hot Reference	30.810 A † 6.902 B	3.305 1.159	10 12	*t*-test for unequal variances	6.76

(Sheet 3 of 6)

Table A17 (Continued)

Contaminant	Organism	Sediment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
Pyrene (ng/g wet wt.)	Mussel	Hot	854.583 A	176.703	12	*t*-test for unequal variances	275
		Reference	11.592 B	1.555	12		
	Clam	Hot	1854.17 A	109.194	12	LSD test (log-transformed data)	227
		Reference	11.33 B	0.909	12		
	Fish	Hot	† 10.000 A	6.680	10	Nonparametric LSD test (data converted to rankits)	13.0
		Reference	†† 0.097 B	0.008	12		
Cd (µg/g dry wt.)	Mussel	Inner	4.857 C	0.247	12	LSD test (log-transformed data)	0.98
		Outer	9.048 A	0.561	12		
		Hot	6.639 B	0.254	12		
		Reference	3.419 D	0.160	12		
	Clam	Inner	0.381 AB	0.032	12	*t*-tests	0.08
		Outer	0.327 A	0.029	5		
		Hot	0.295 B	0.026	12		
		Reference	0.402 A	0.017	12		
	Fish	Inner	0.418 B	0.014	12	*t*-tests	0.06
		Outer	0.585 A	0.023	11		
		Hot	0.377 B	0.034	12		
		Reference	0.393 B	0.010	12		
Cr (µg/g dry wt.)	Mussel	Inner	1.570 C	0.233	12	LSD test (log-transformed data)	0.89
		Outer	2.400 B	0.471	12		
		Hot	3.808 A	0.326	12		
		Reference	0.667 D	0.057	12		
	Clam	Inner	10.285 AB	2.472	12	*t*-tests (log-transformed data)	5.44
		Outer	9.844 AB	5.228	5		
		Hot	4.667 B	0.521	12		
		Reference	7.992 A	0.351	12		
	Fish	Inner	1.463 AB	0.574	12	Nonparametric *t*-tests (data converted to rankits)	0.91
		Outer	0.872 B	0.208	11		
		Hot	0.884 AB	0.080	12		
		Reference	1.072 A	0.116	12		
Hg (µg/g dry wt.)	Mussel	Inner	0.199 C	0.012	12	*t*-tests	0.04
		Outer	0.594 A	0.024	12		
		Hot	0.297 B	0.009	12		
		Reference	0.153 D	0.006	12		
	Clam	Inner	0.120 B	0.029	12	Nonparametric *t*-tests (data converted to rankits)	0.06
		Outer	† 0.058 B	0.036	5		
		Hot	0.154 A	0.008	12		
		Reference	0.152 A	0.006	12		
	Fish	Inner	0.390 AB	0.057	12	*t*-tests	0.10
		Outer	0.355 A	0.014	11		
		Hot	0.270 BC	0.035	12		
		Reference	0.255 C	0.005	12		

(Sheet 4 of 6)

Table A17 (Continued)							
Contaminant	**Organism**	**Sediment**	**Mean Concentration**	**Standard Error**	**N**	**Test Used for Statistical Comparisons**	**LSD d_{min}[1]**
TBT (ng/g dry wt.)	Mussel	Inner Hot Reference	† 5.416 C 341.018 A 108.369 B	1.477 53.452 9.925	12 11 12	Nonparametric LSD test (data converted to rankits)	81.1
	Clam	Inner Hot Reference	† 13.628 B 152.004 A 135.424 A	2.449 26.548 7.397	12 11 12	Nonparametric LSD test (data converted to rankits)	43.8
	Fish	Inner Hot Reference	† 1.293 B 50.935 A 59.542 A	1.001 5.062 8.193	12 3 11	Nonparametric LSD test (data converted to rankits)	17.5
DBT (ng/g dry wt.)	Mussel	Inner Hot Reference	16.433 B 65.794 A 46.512 A	1.917 9.399 5.034	12 11 12	LSD test (log-transformed data)	15.0
	Clam	Inner Hot Reference	† 7.601 B 26.235 A † 14.731 B	2.012 3.589 1.809	12 11 12	LSD test	7.25
	Fish	Inner Hot Reference	† 0.790 A †† 3.147 A †† 1.253 A	0.555 0.479 0.071	12 3 11	Nonparametric *t*-tests (data converted to rankits)	1.35
MBT (ng/g dry wt.)	Mussel	Inner Hot Reference	†† 0.242 B † 2.786 A †† 1.476 B	0.005 0.503 0.149	12 11 12	Nonparametric LSD test (data converted to rankits)	0.81
	Clam	Inner Hot Reference	†† 0.239 B †† 3.166 B † 21.129 A	0.003 0.472 8.022	12 11 12	Nonparametric LSD test (data converted to rankits)	13.3
Aroclor 1254 (ng/g wet wt.)	Mussel	Outer Hot Reference	74.667 A 83.042 A †† 2.000 B	11.703 6.477 0	12 12 12	Nonparametric *t*-tests (data converted to rankits)	19.6
	clam	Outer Hot Reference	65.909 A 65.000 A †† 2.000 B	31.464 -- 0	11 1 12	Nonparametric *t*-tests (data converted to rankits)	76.7
	Fish	Outer Hot Reference	197.100 A 44.714 B †† 2.000 C	82.489 2.925 0	10 7 12	nonparametric *t*-tests (data converted to rankits)	144

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Table A17 (Concluded)

Contaminant	Organism	Sediment	Mean Concentration	Standard Error	N	Test Used for Statistical Comparisons	LSD d_{min}[1]
Lipid (percent wet wt.)	Mussel	Inner	2.928 A	0.474	12	*t*-tests (log-transformed data)	0.71
		Outer	1.657 B	0.151	11		
		Hot	1.566 B	0.066	12		
		Reference	2.202 A	0.077	12		
	Clam	Inner	1.405 B	0.164	11	LSD test (log-transformed data)	0.77
		Outer	2.062 A	0.319	5		
		Hot	3.034 A	0.373	12		
		Reference	1.341 B	0.120	12		
	Fish	Inner	1.349 A	0.085	12	LSD test	0.22
		Outer	1.296 A	0.096	9		
		Hot	1.264 A	0.073	10		
		Reference	1.092 A	0.045	12		

Appendix B

Figures Showing Results of Statistical Comparisons for Primary Contaminants of Concern

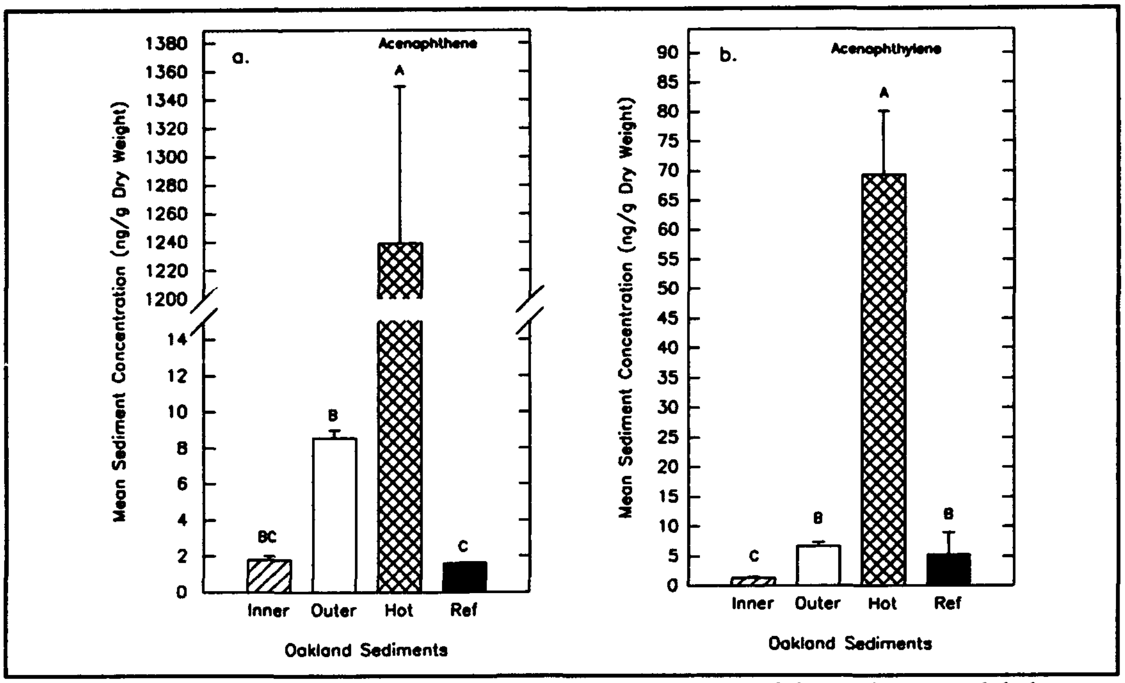

Figure B1. PAH concentrations in sediments: means +SE. a. Acenaphthene. b. Acenaphthylene. For each PAH, bars with same letter not significantly different ($P_{\alpha/2} > 0.025$)

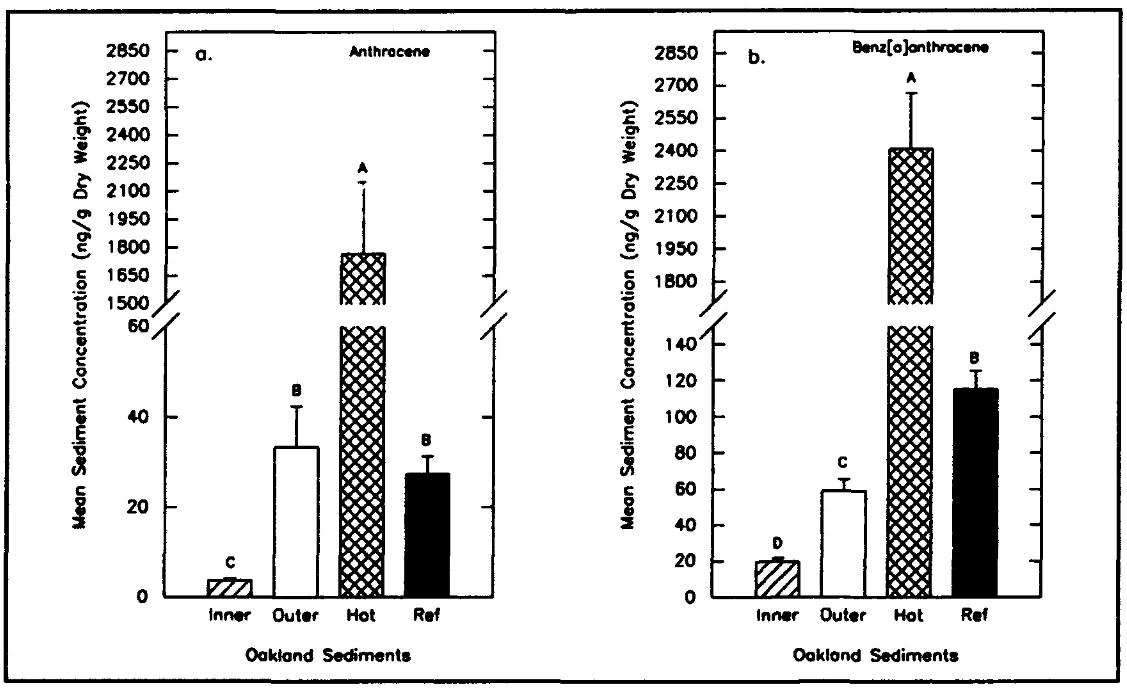

Figure B2. PAH concentrations in sediments. a. Anthracene. b. Benz[a]anthracene

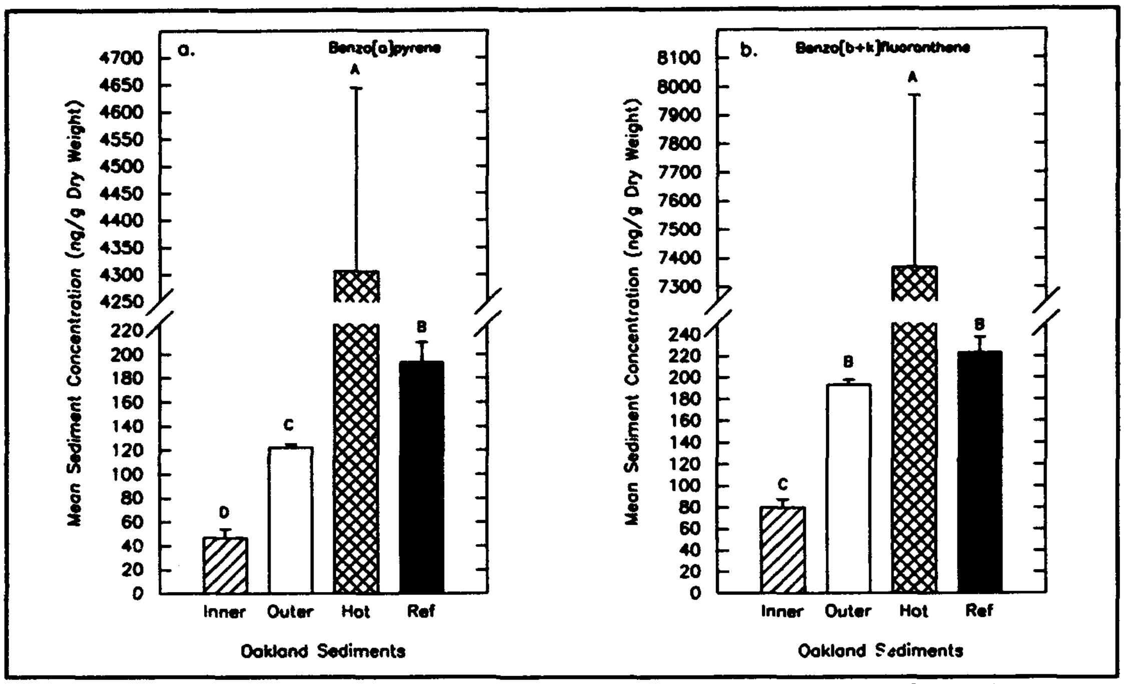

Figure B3. PAH concentrations in sediments. a. Benzo[a]pyrene. b. Benzo[b+k]fluoranthene

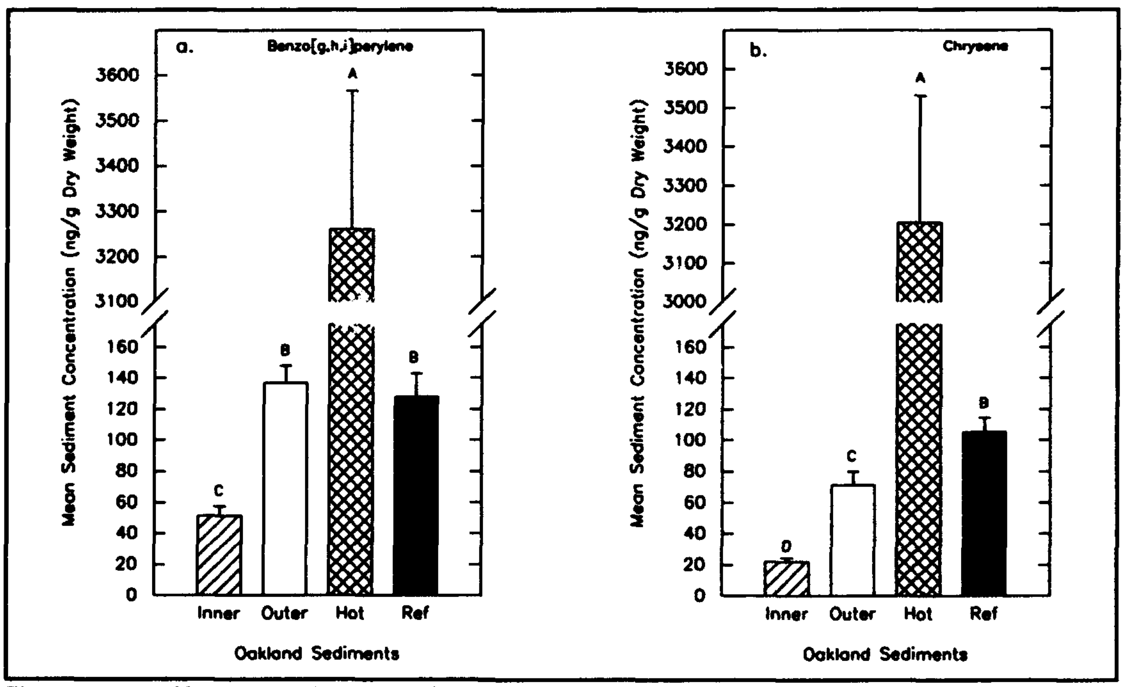

Figure B4. PAH concentrations in sediments. a. Benzo[g,h,i]perylene. b. Chrysene

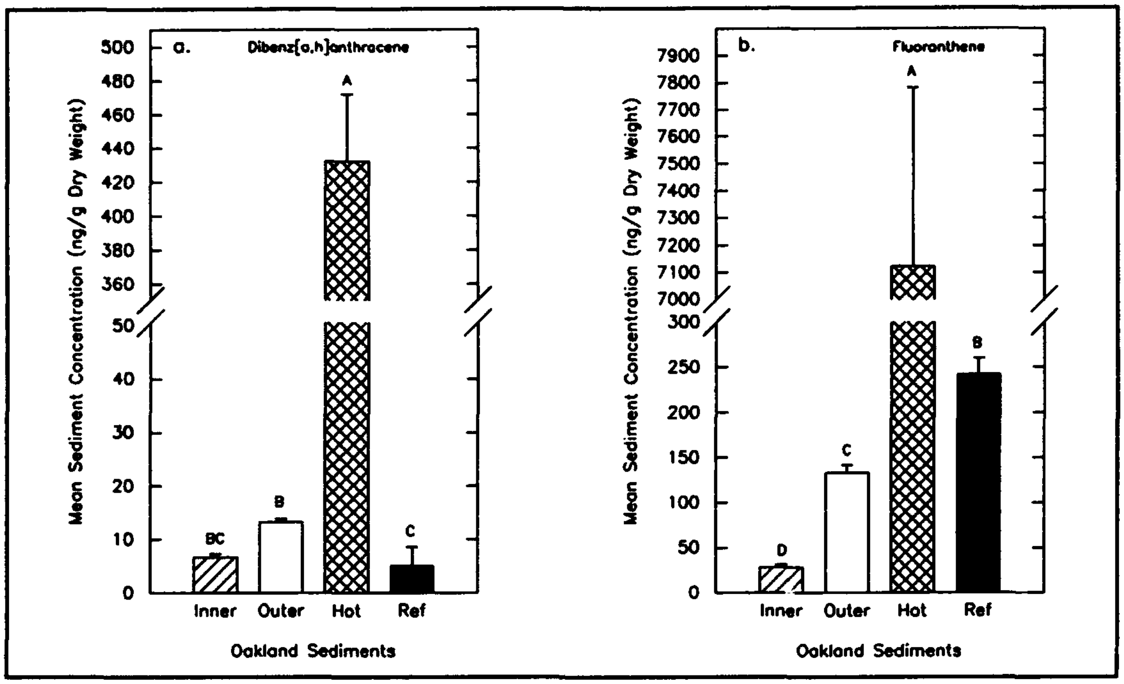

Figure B5. PAH concentrations in sediments. a. Dibenz[a,h]anthracene. b. Fluoranthene

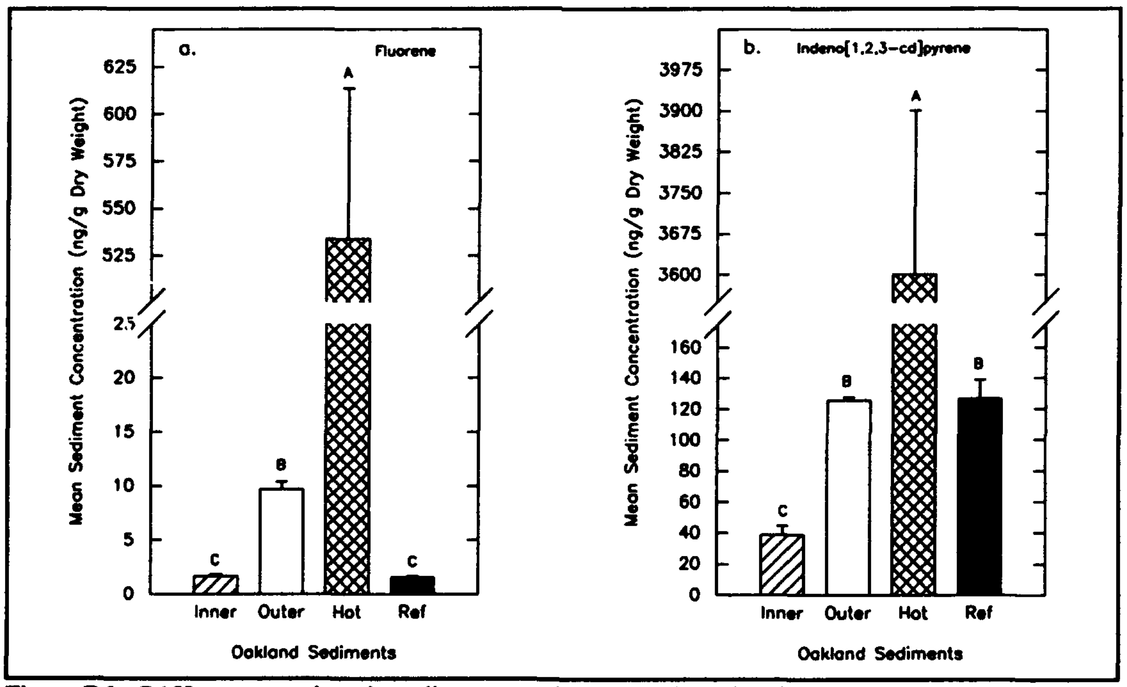

Figure B6. PAH concentrations in sediments. a. Fluorene. b. Indeno[1,2,3-cd]pyrene

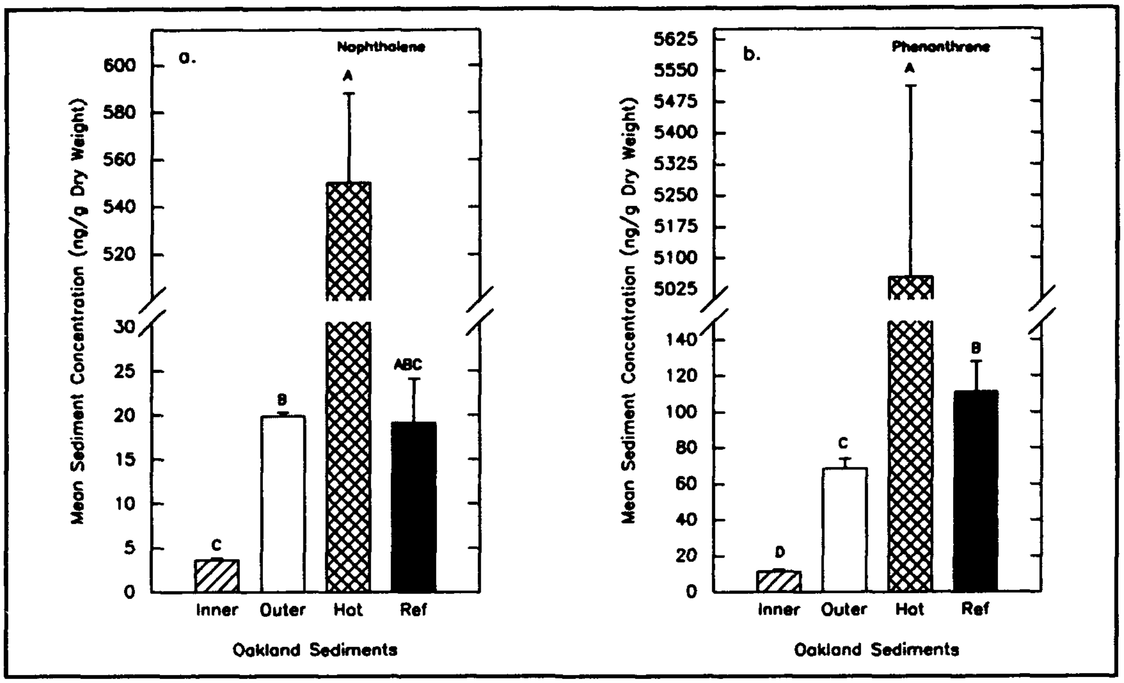

Figure B7. PAH concentrations in sediments. a. Naphthalene. b. Phenanthrene

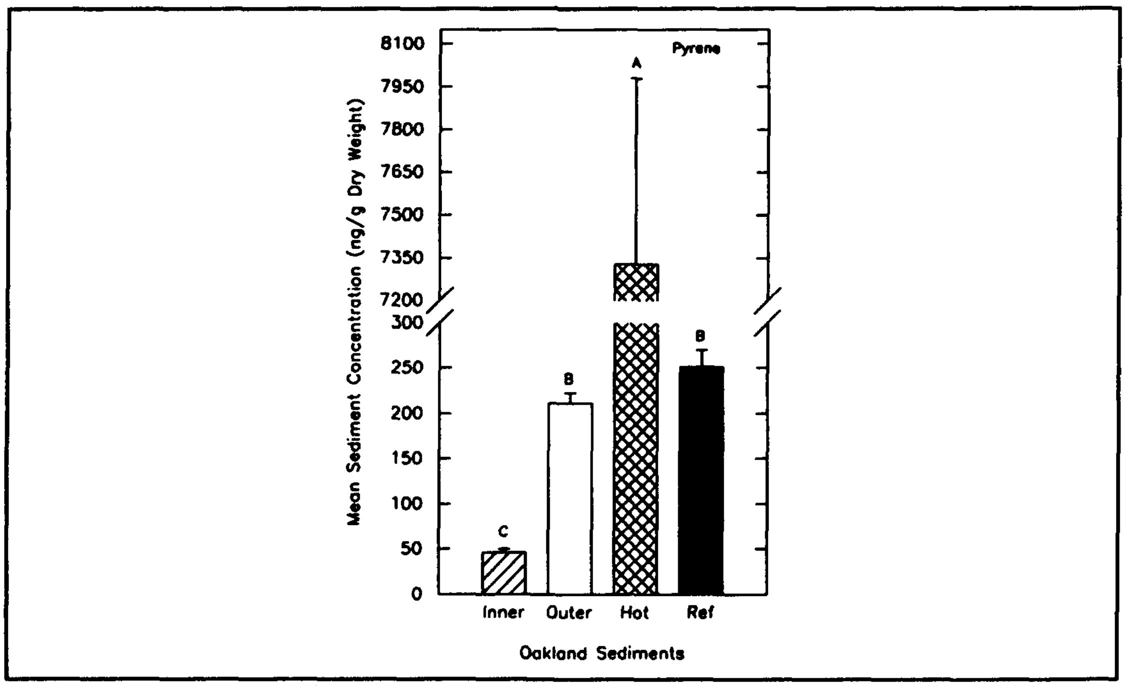

Figure B8. PAH concentrations in sediments: pyrene

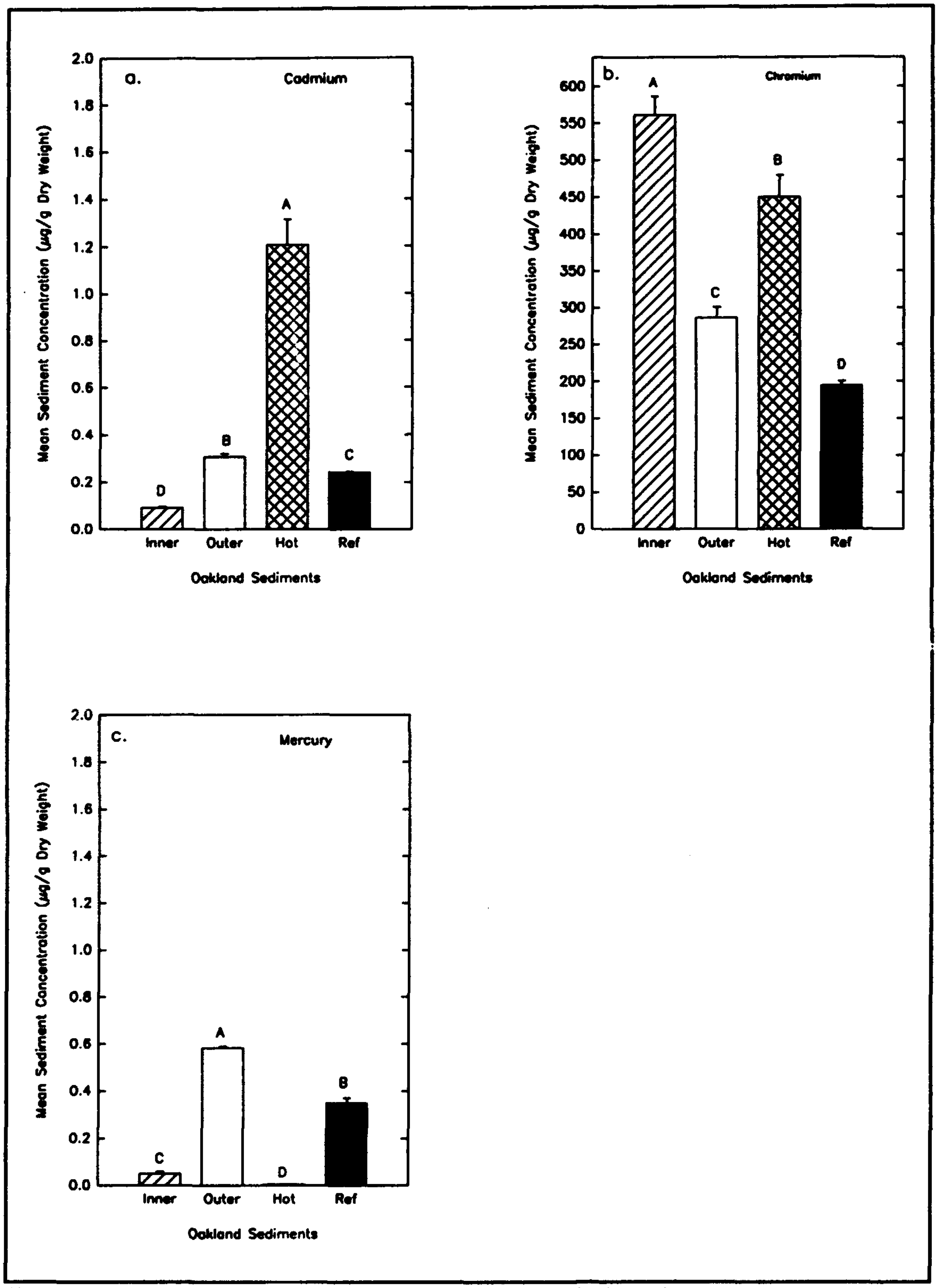

Figure B9. Metal concentrations in sediments. a. Cadmium. b. Chromium. c. Mercury

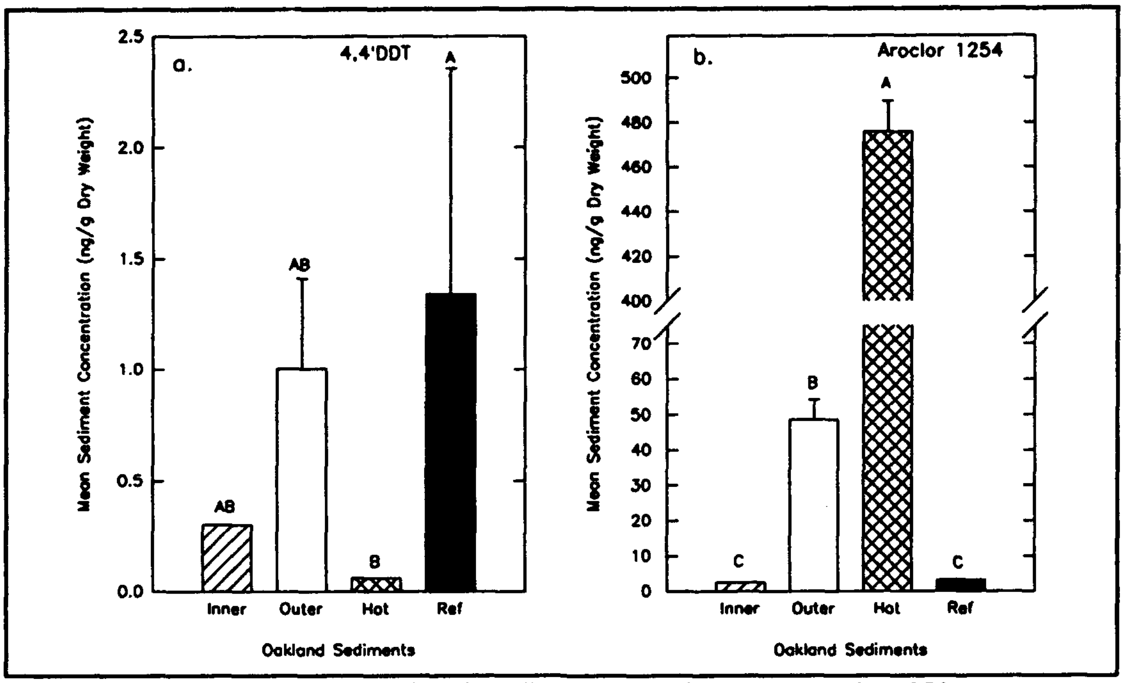

Figure B10. Contaminant concentrations in sediments. a. 4,4'DDT. b. Aroclor 1254

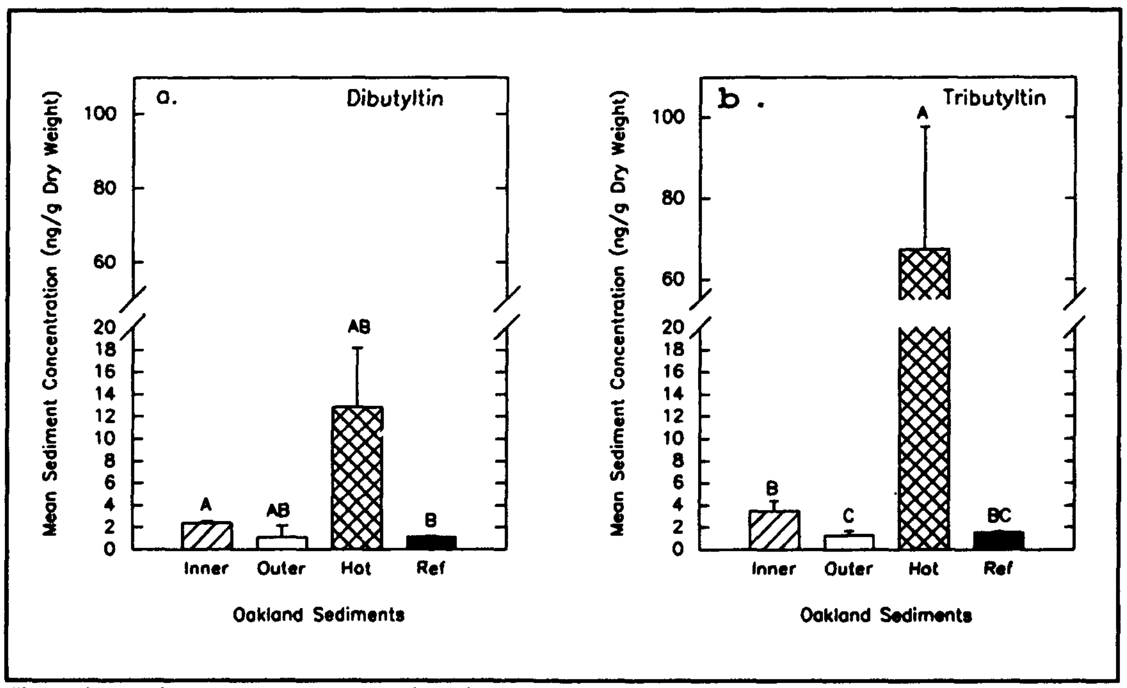

Figure B11. Contaminant concentrations in sediments. a. Dibutyltin. b. Tributyltin

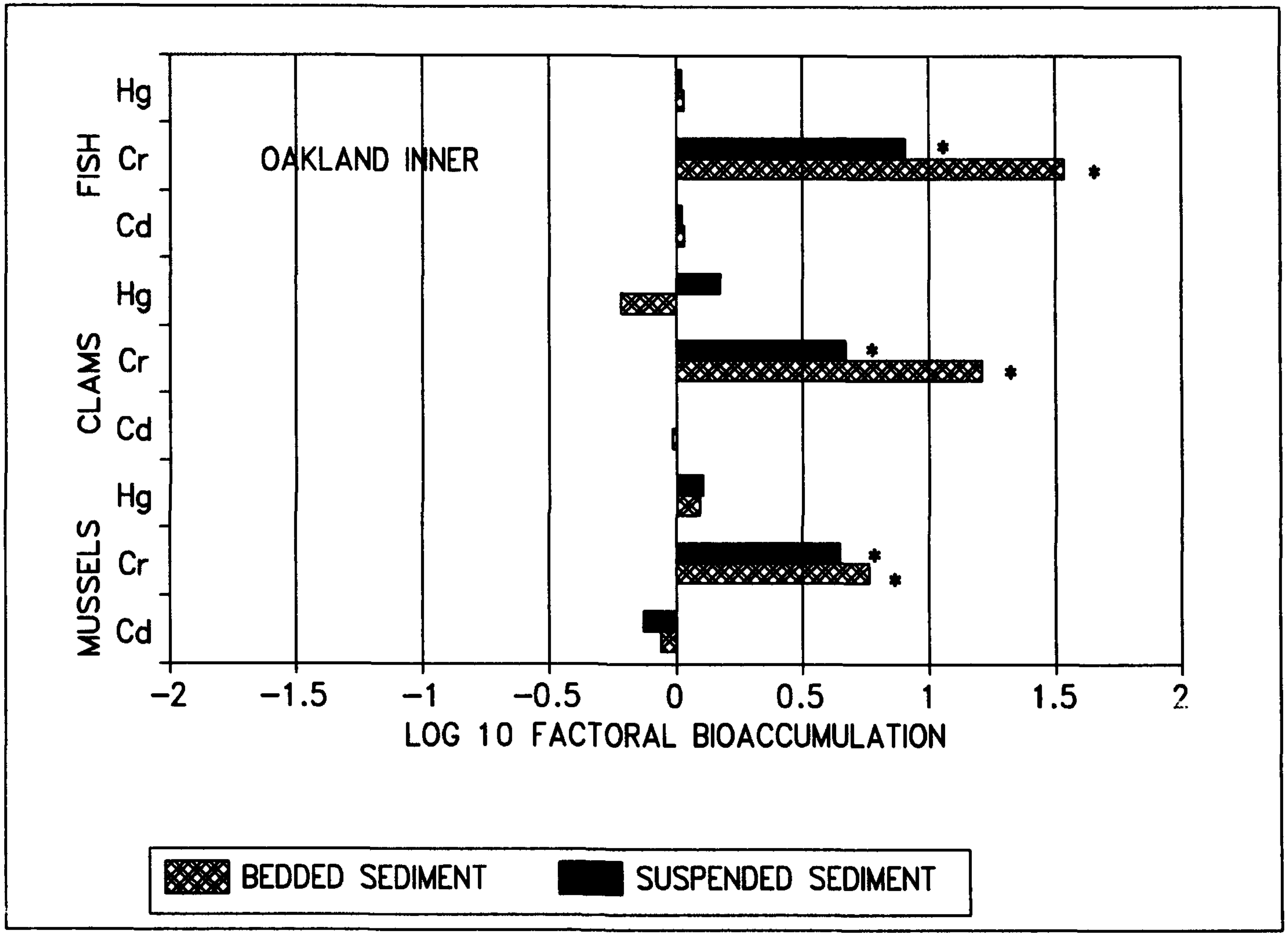

Figure B12. Bioaccumulation of metals from Inner BS and S50 after 28 days exposure. Log_{10}([exposed]/[background]). * Exposed significantly different from background ($P_{\alpha/2} \leq 0.025$)

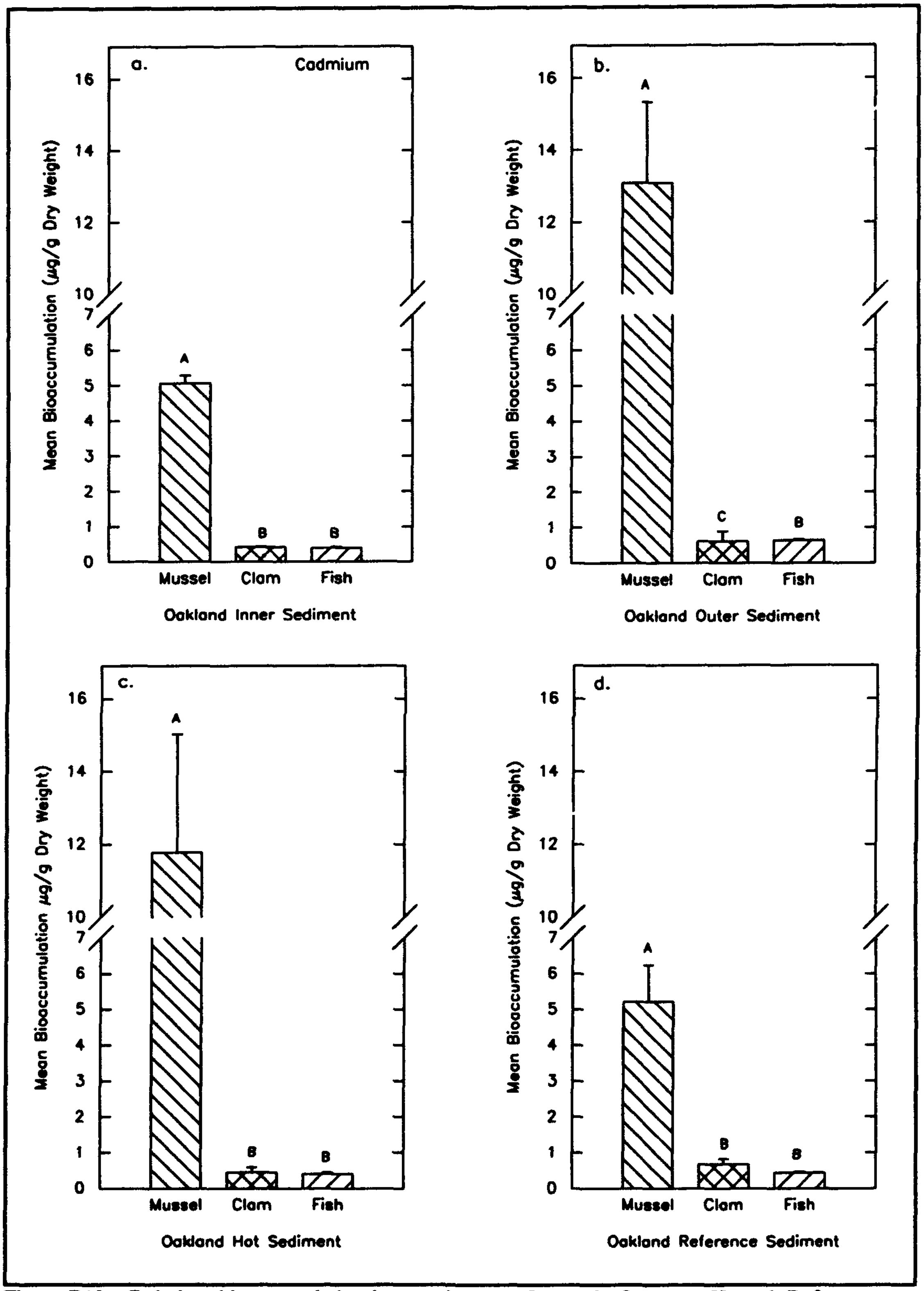

Figure B13. Cadmium bioaccumulation in organisms. a. Inner. b. Outer. c. Hot. d. Reference. For each sediment, bars with same letter are not significantly different ($P_{\alpha/2} > 0.025$)

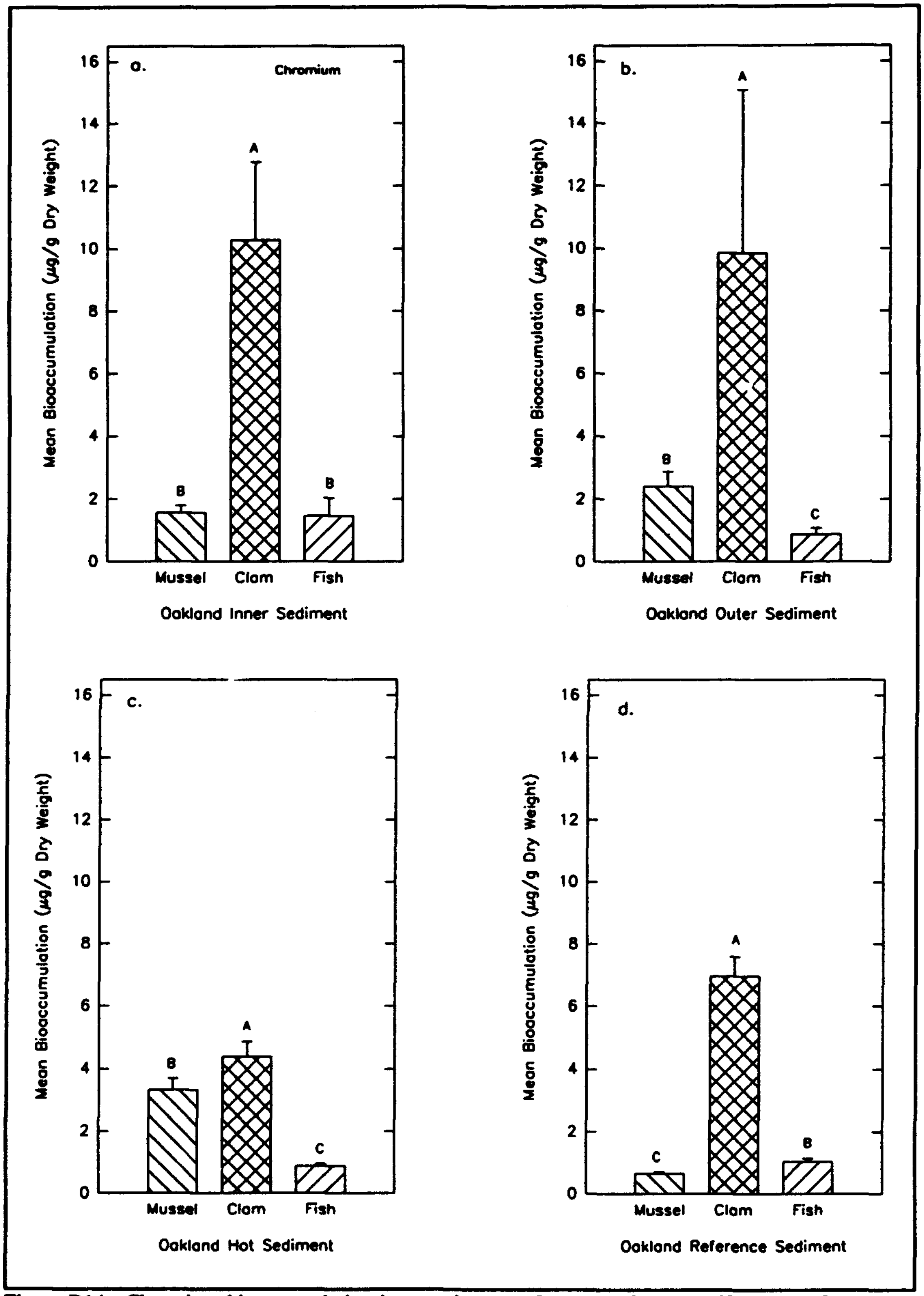

Figure B14. Chromium bioaccumulation in organisms. a. Inner. b. Outer. c. Hot. d. Reference

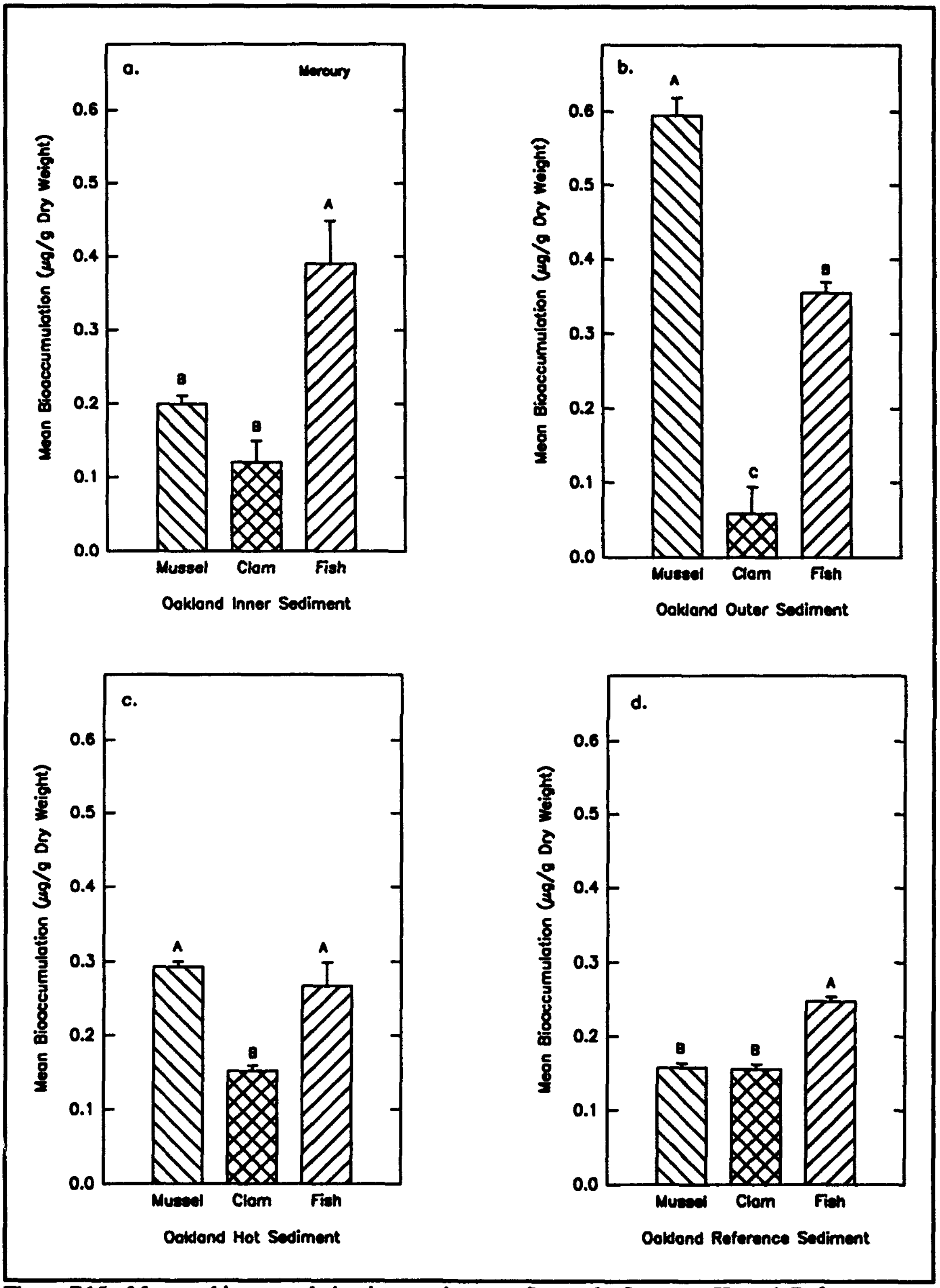

Figure B15. Mercury bioaccumulation in organisms. a. Inner. b. Outer. c. Hot. d. Reference

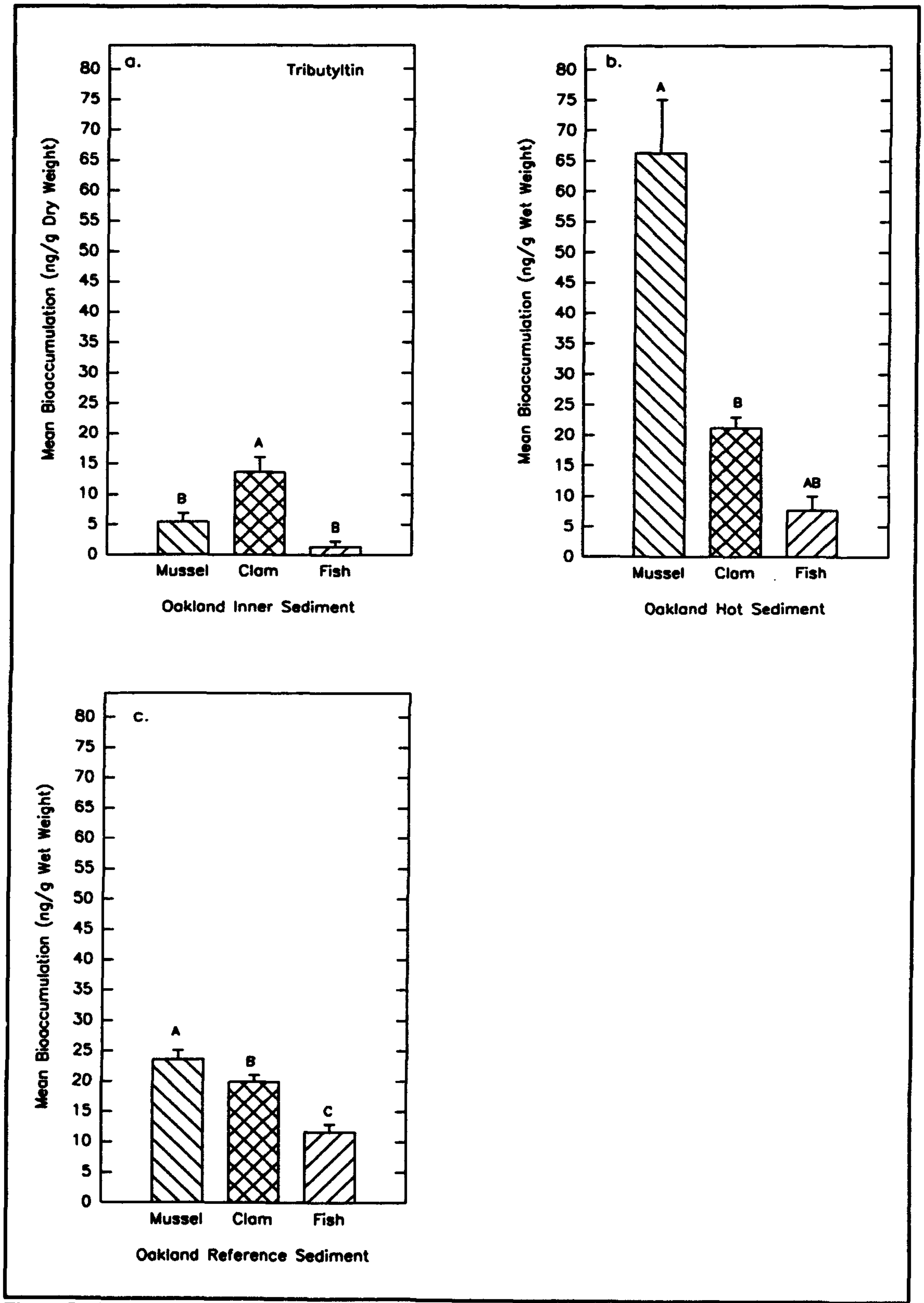

Figure B16. Tributyltin bioaccumulation in organisms. a. Inner. b. Hot. c. Reference

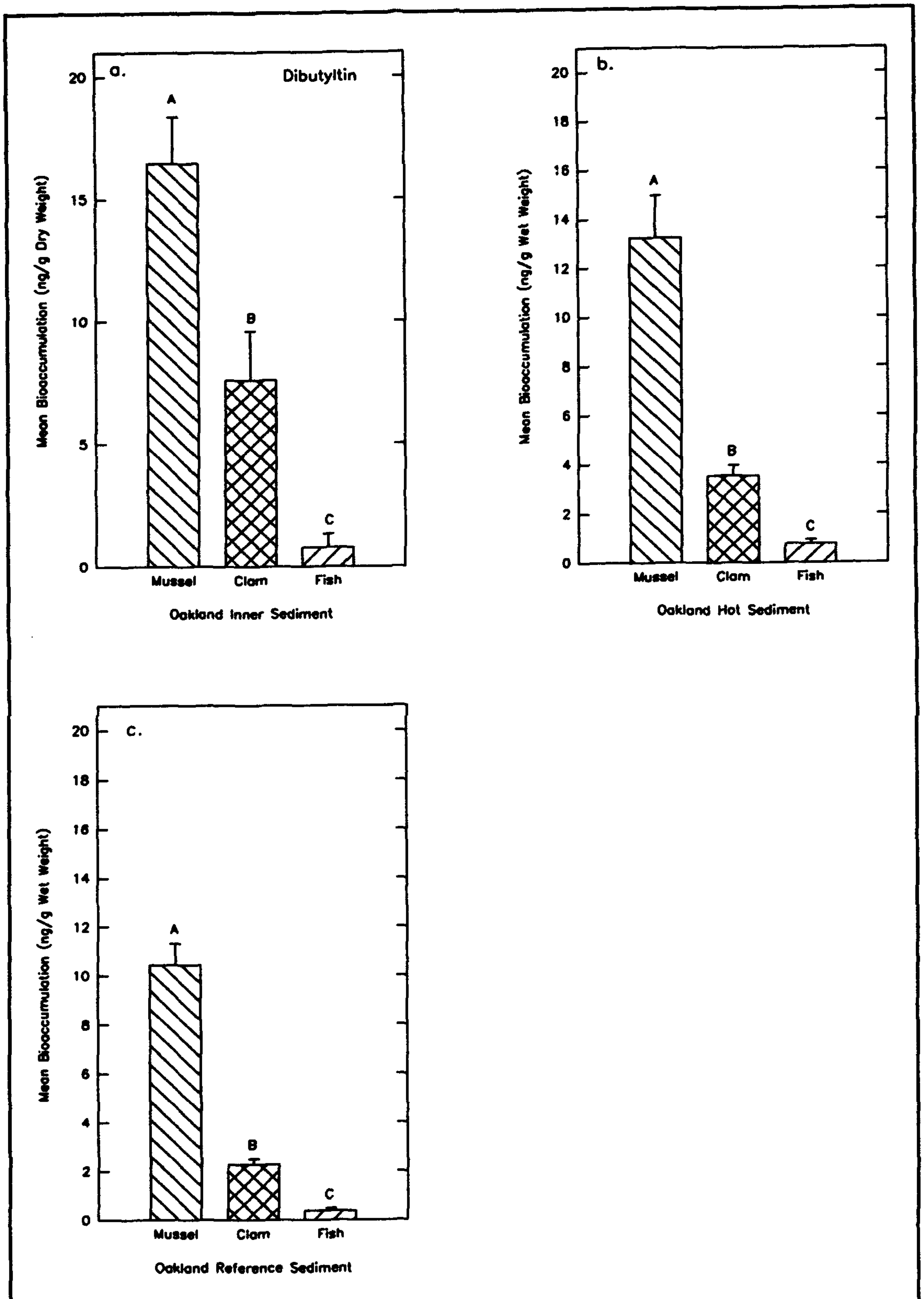

Figure B17. Dibutyltin bioaccumulation in organisms. a. Inner. b. Hot. c. Reference

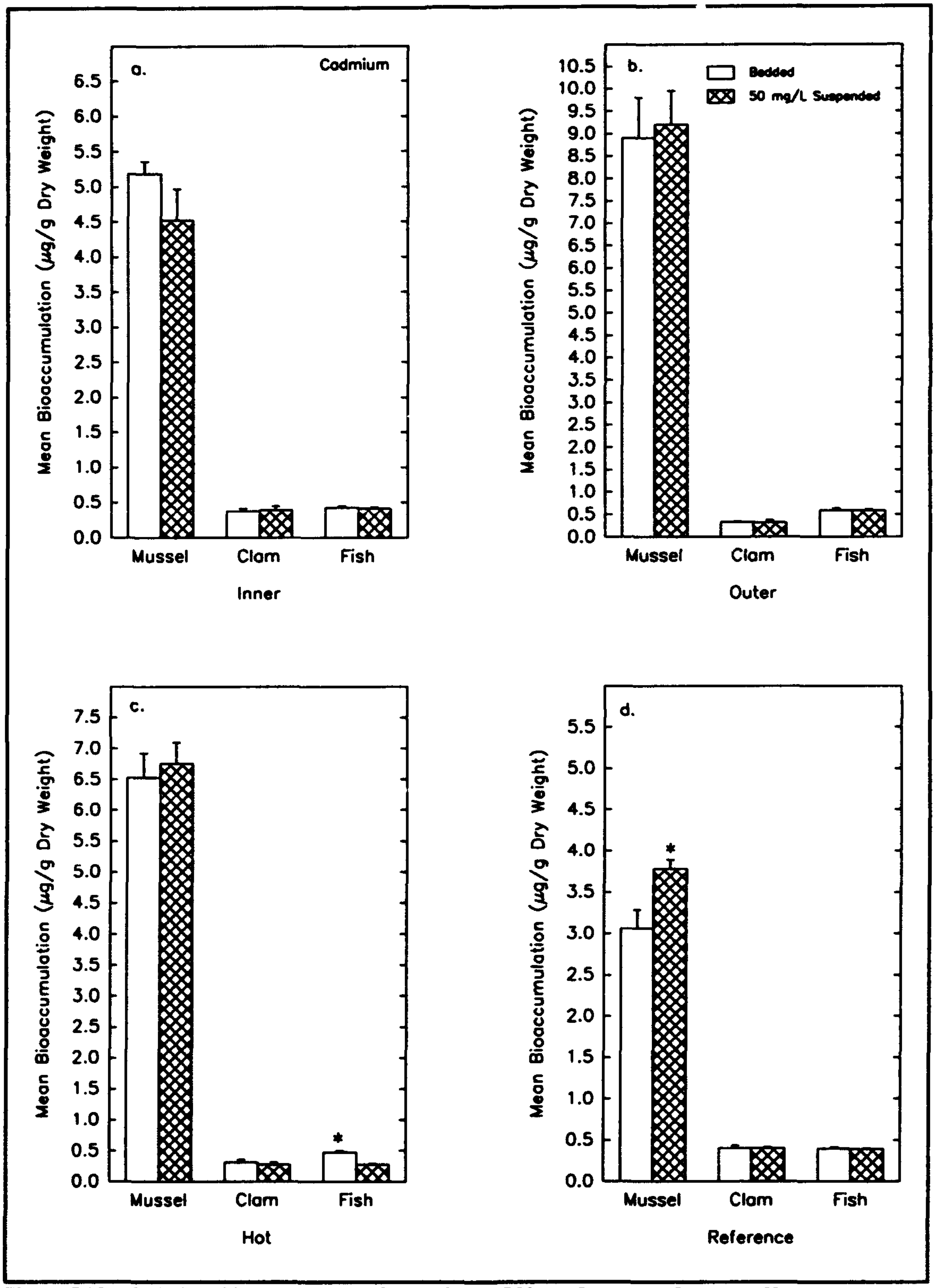

Figure B18. Cadmium bioaccumulation from BS and S50. a. Inner. b. Outer. c. Hot. d. Reference. * BS significantly different from S50 ($P_{\alpha/2} \leq 0.025$)

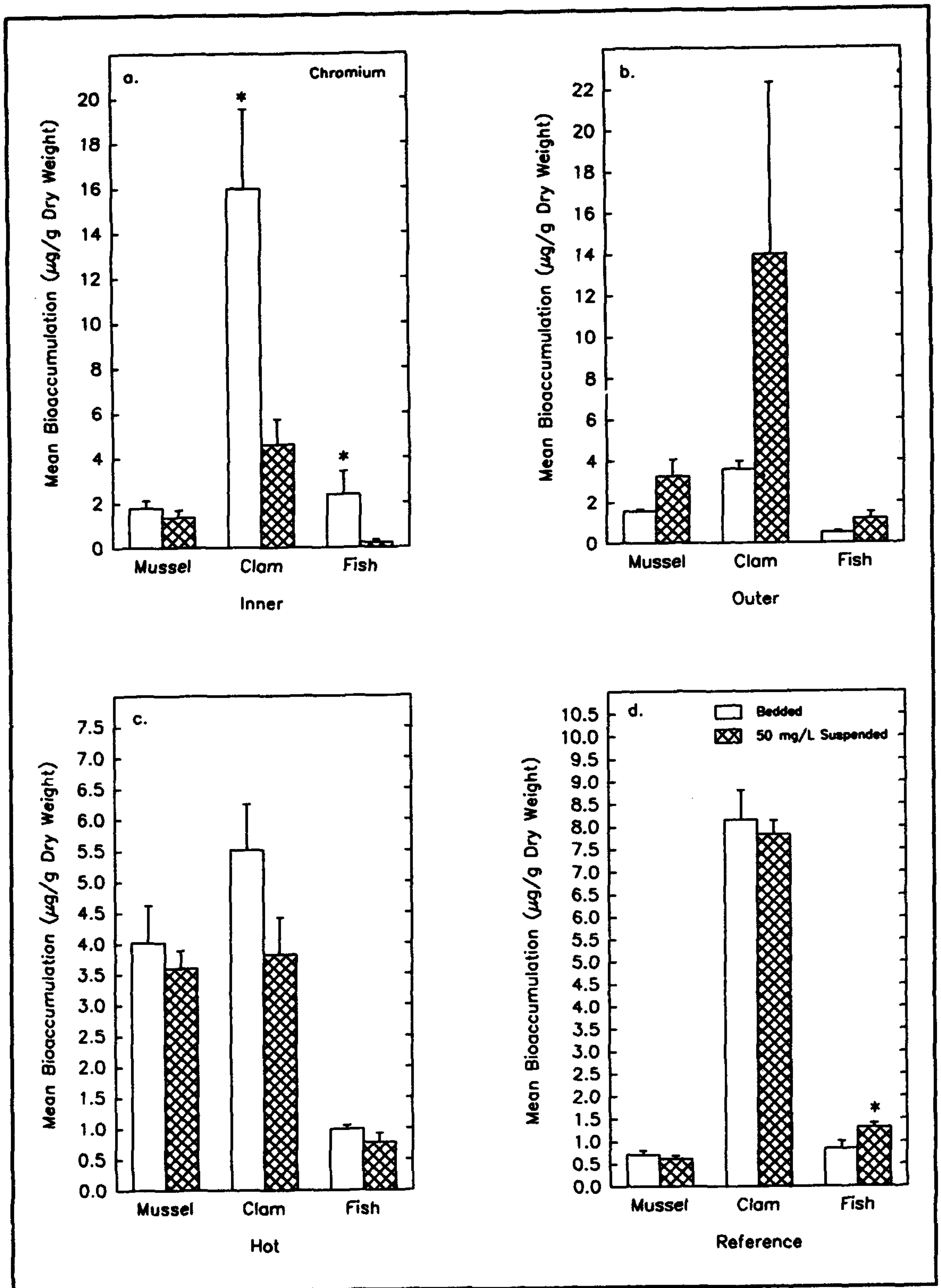

Figure B19. Chromium bioaccumulation from BS and S50. a. Inner. b. Outer. c. Hot. d. Reference

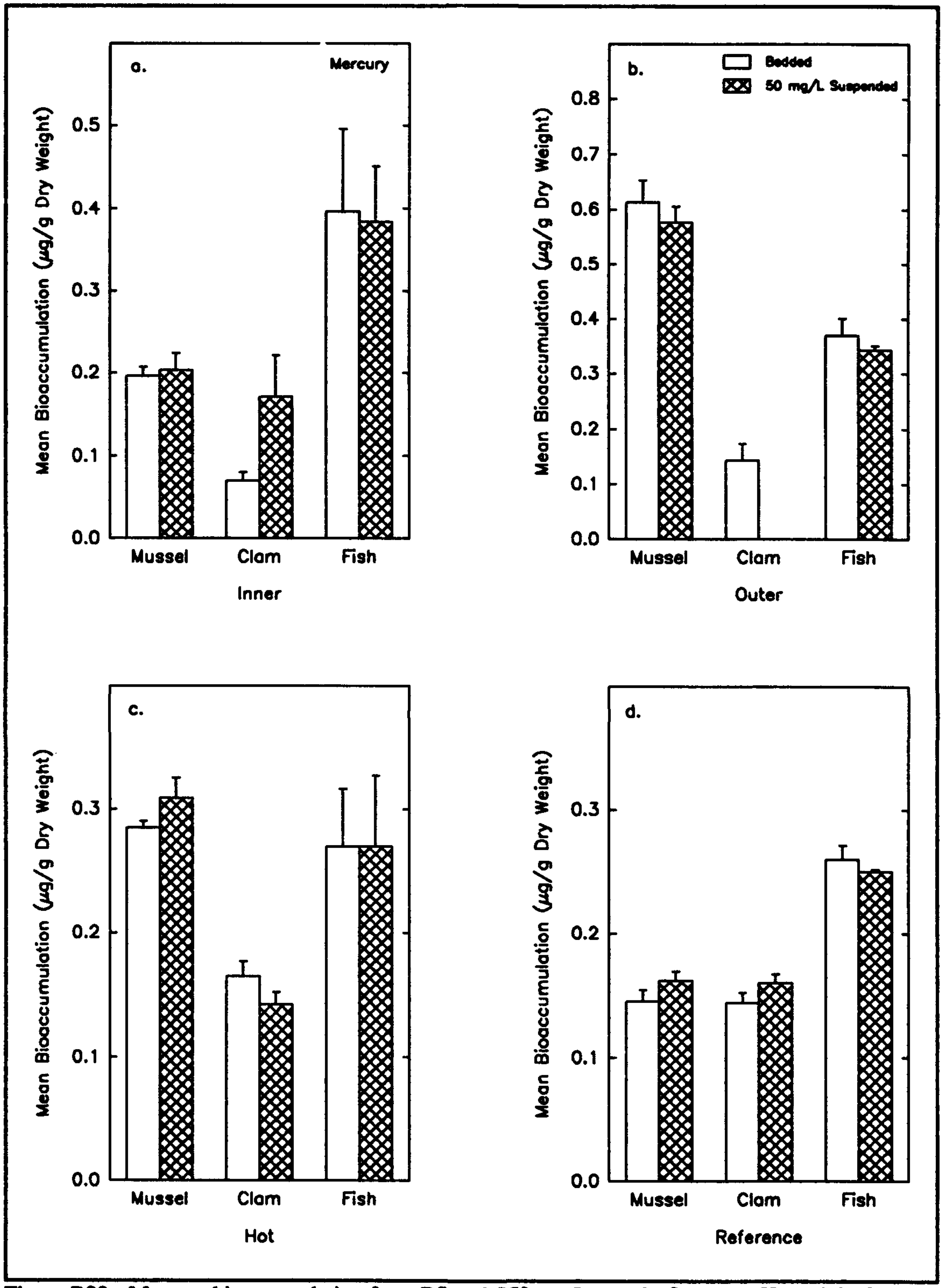

Figure B20. Mercury bioaccumulation from BS and S50. a. Inner. b. Outer. c. Hot. d. Reference

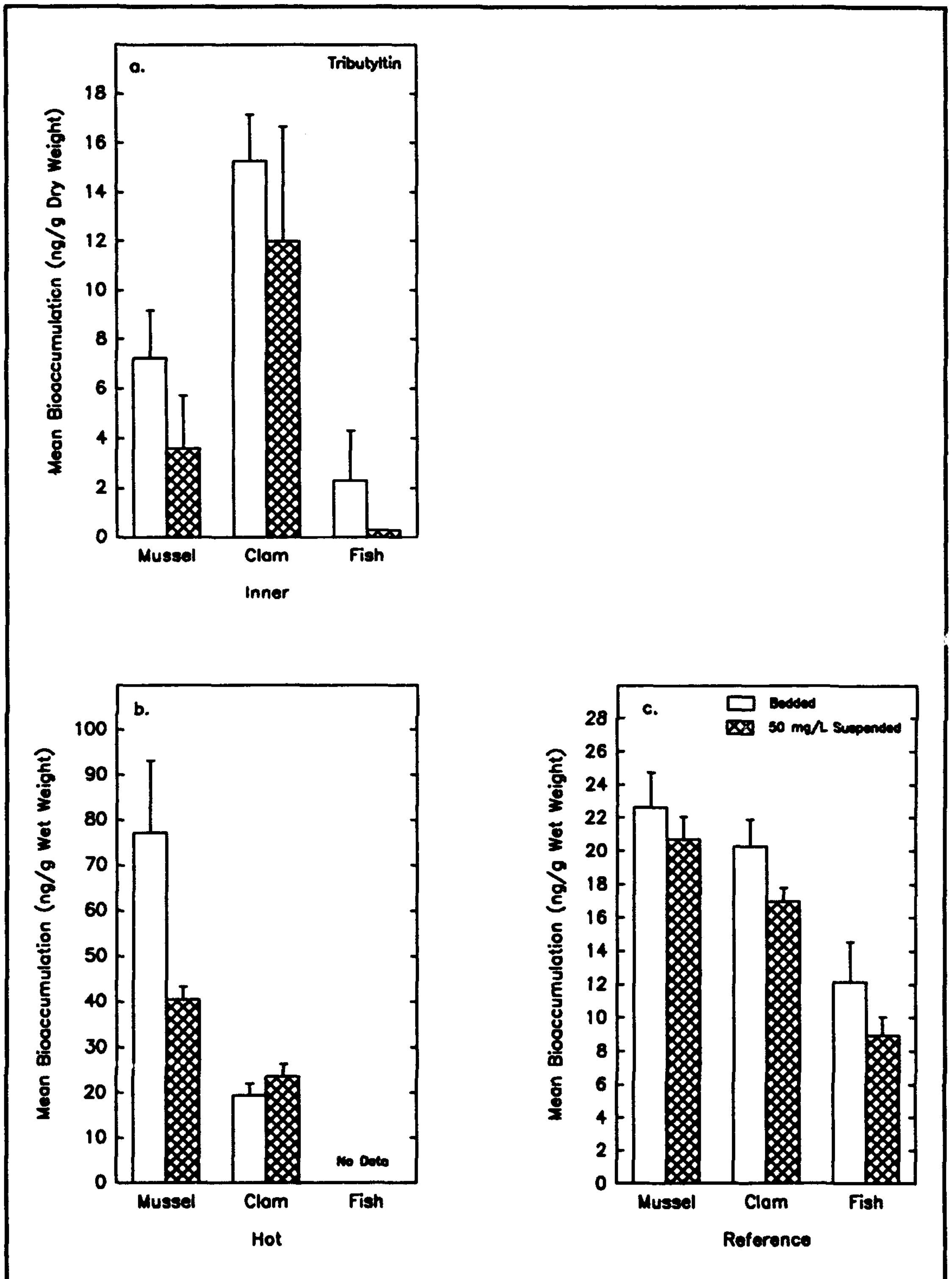

Figure B21. Tributyltin bioaccumulation from BS and S50. a. Inner. b. Hot. c. Reference

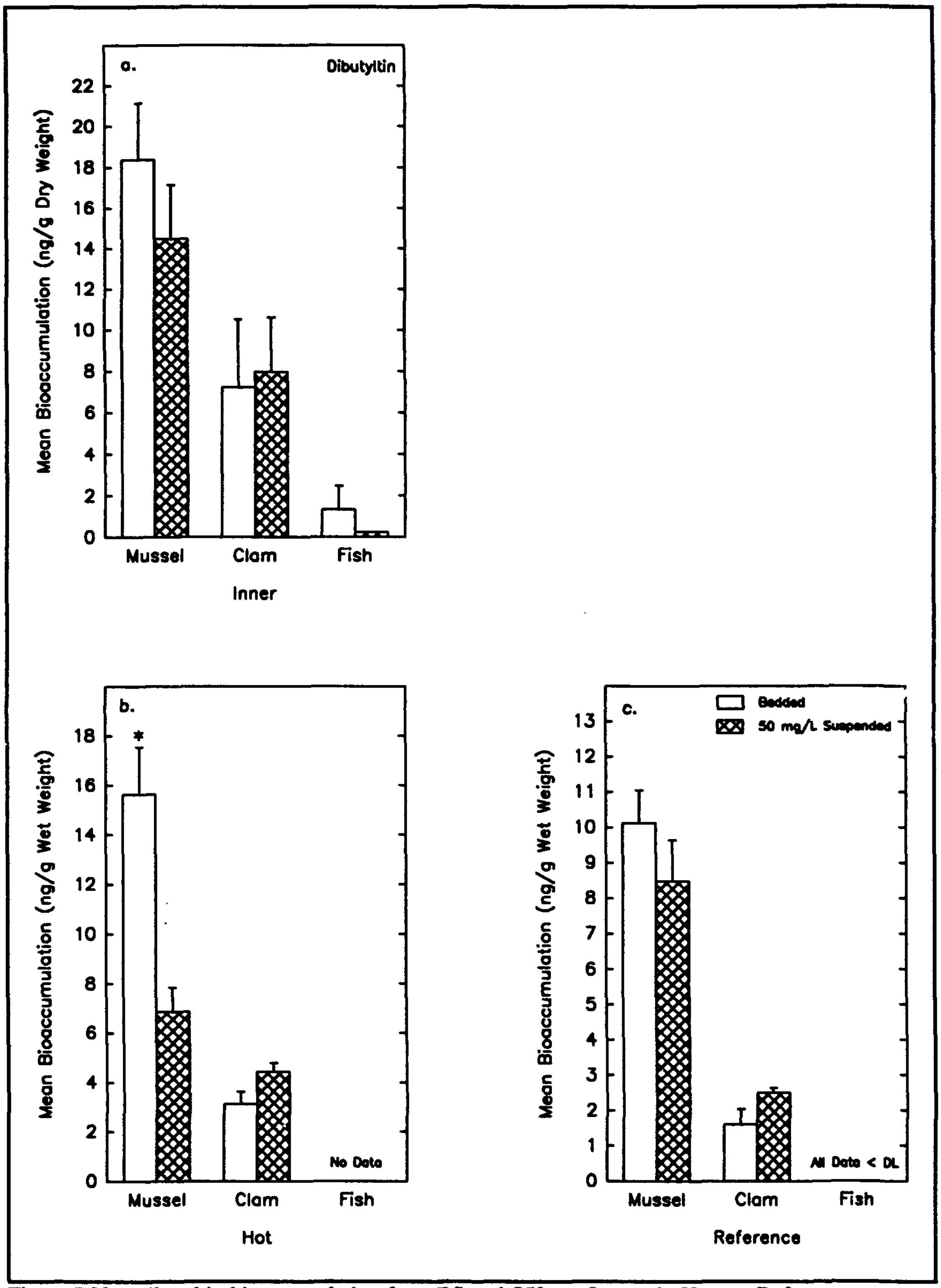

Figure B22. Dibutyltin bioaccumulation from BS and S50. a. Inner. b. Hot. c. Reference

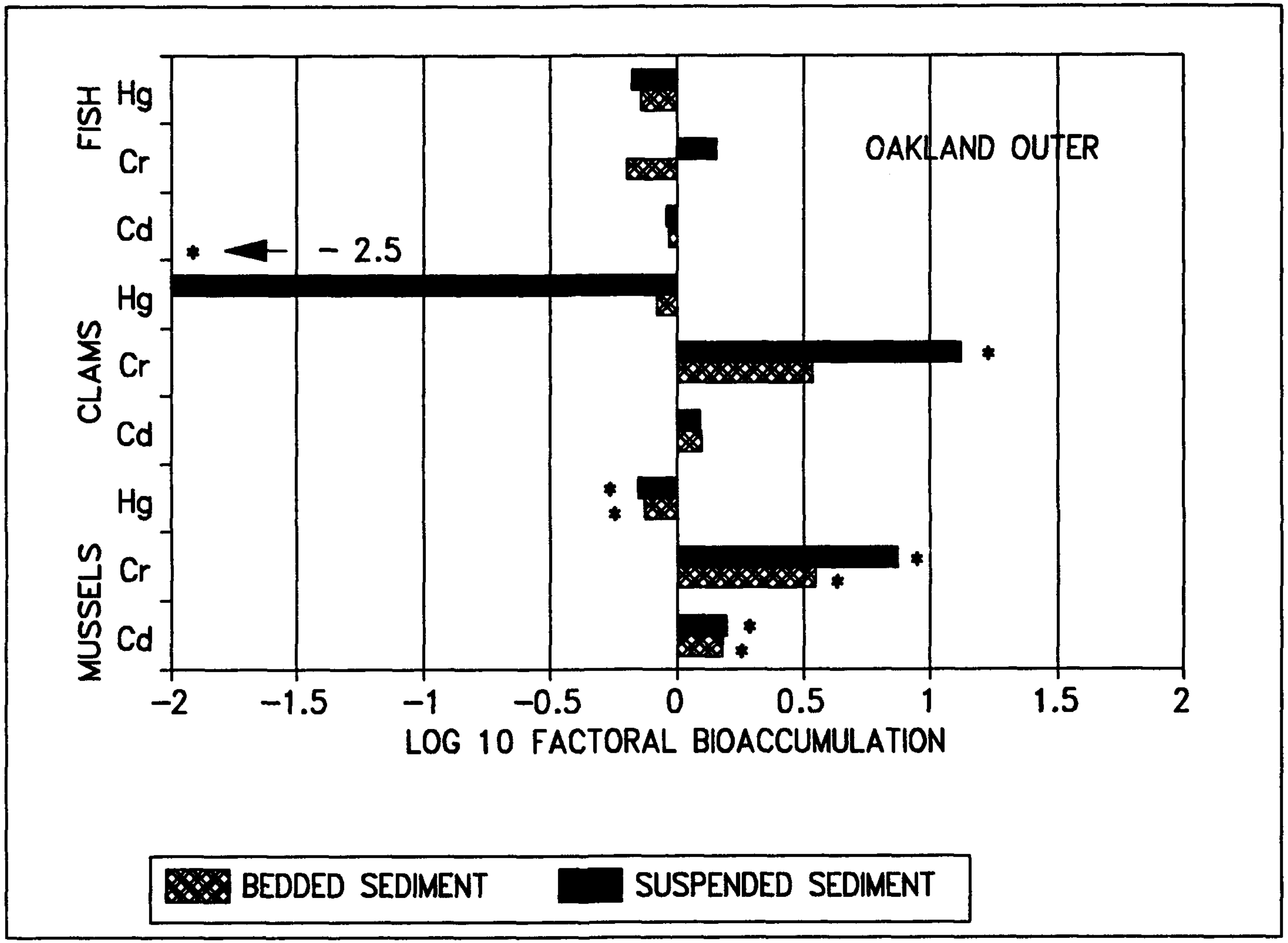

Figure B23. Bioaccumulation of metals from Outer BS and S50 after 28 days exposure. Log_{10}([exposed]/[background]). * Exposed significantly different from background ($P_{\alpha/2} \leq 0.025$)

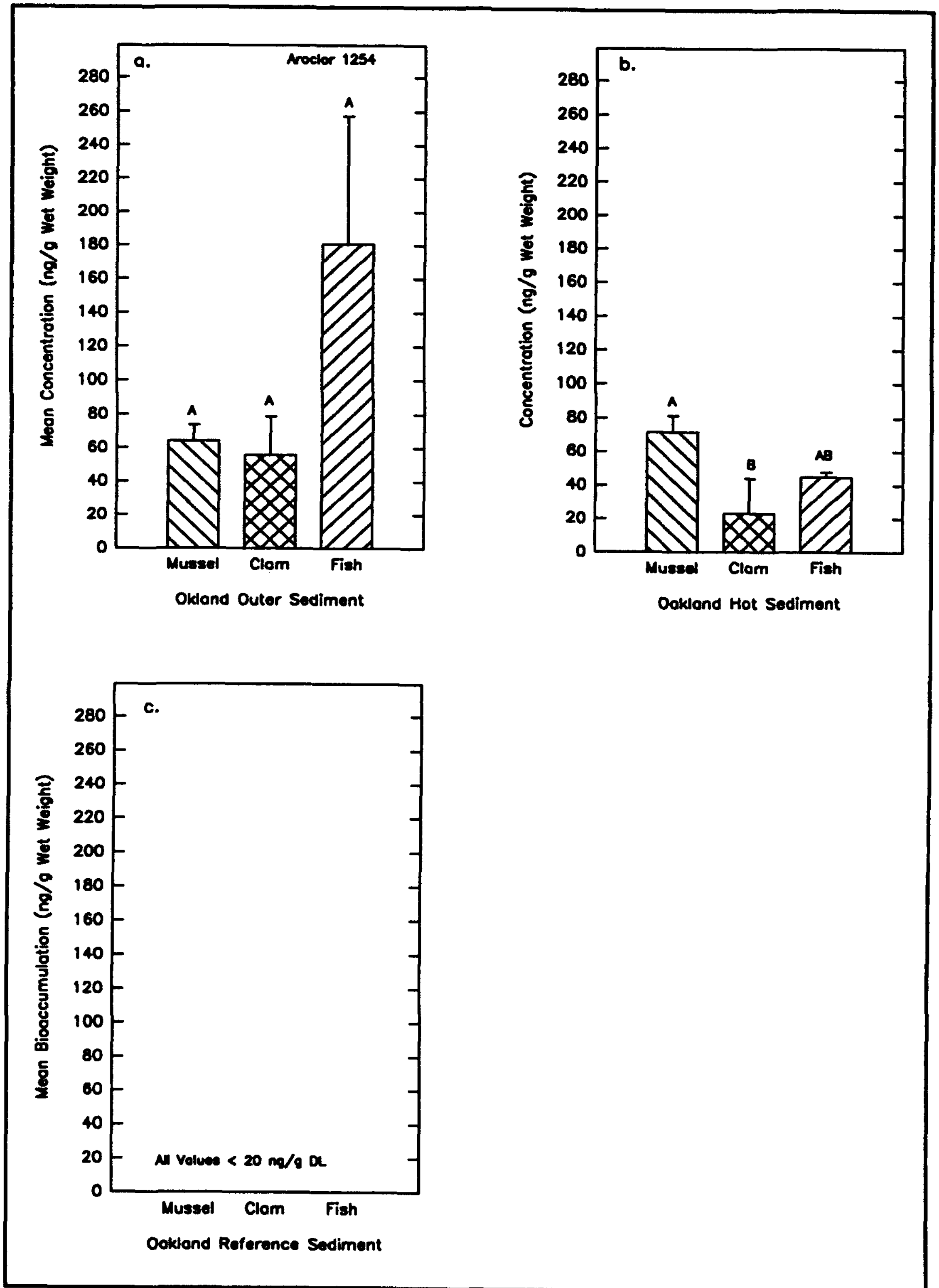

Figure B24. Aroclor 1254 bioaccumulation in organisms. a. Outer. b. Hot. c. Reference. For each sediment, bars with same letter are not significantly different ($P_{\alpha/2} > 0.025$)

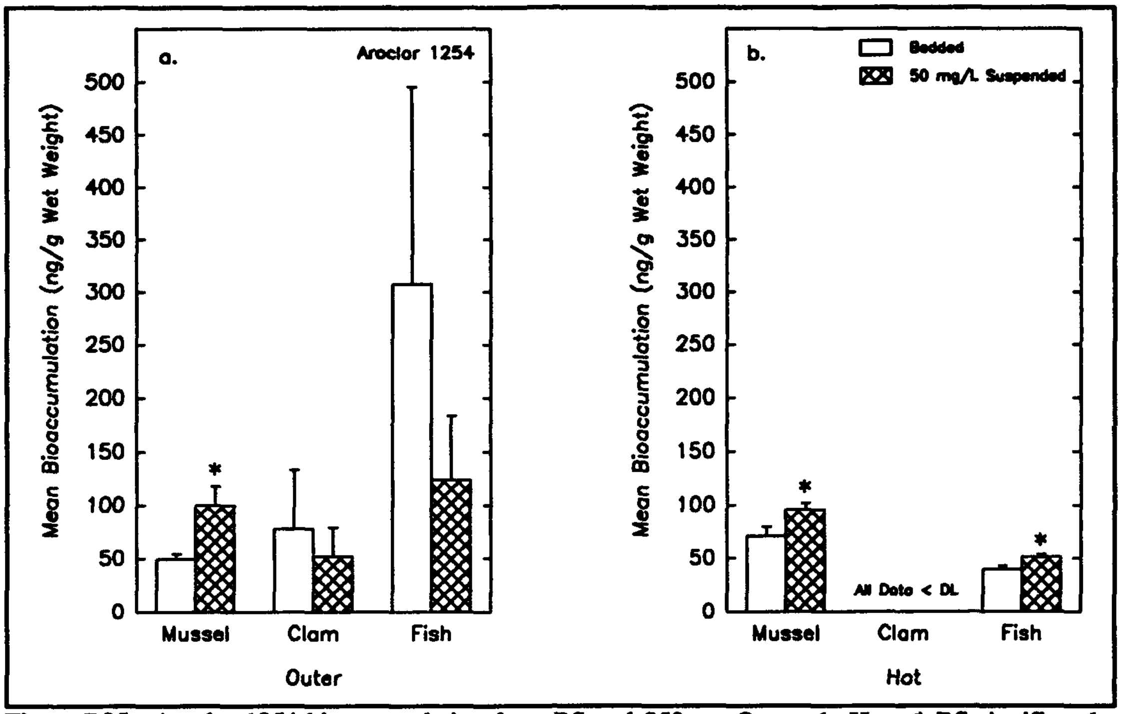

Figure B25. Aroclor 1254 bioaccumulation from BS and S50. a. Outer. b. Hot. * BS significantly different from S50 ($P_{\alpha/2} \leq 0.025$)

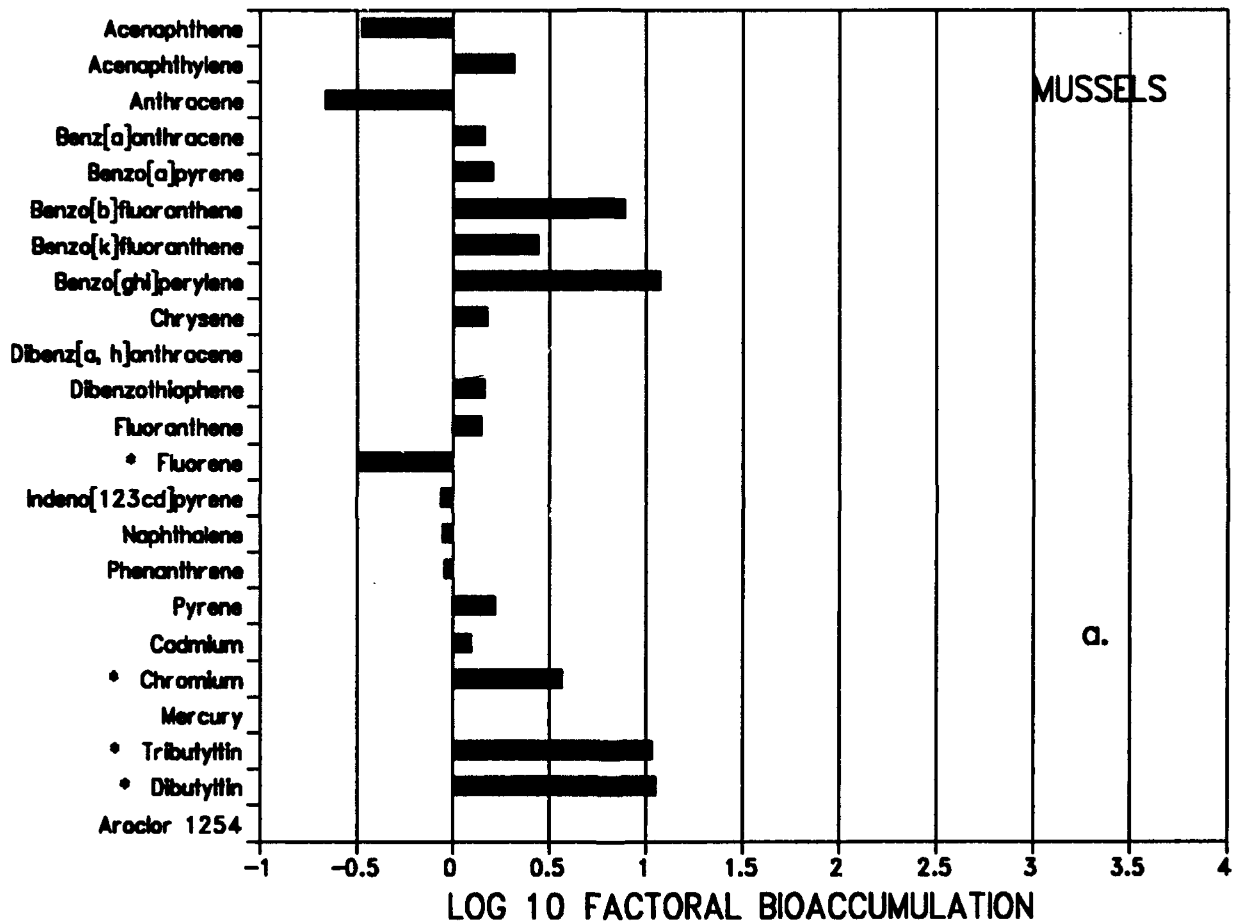

Figure B26. Bioaccumulation in mussels exposed to Reference BS for 28 days. Log_{10}([exposed]/[background]). * Exposed significantly different from background ($P_{\alpha/2} \leq 0.025$)

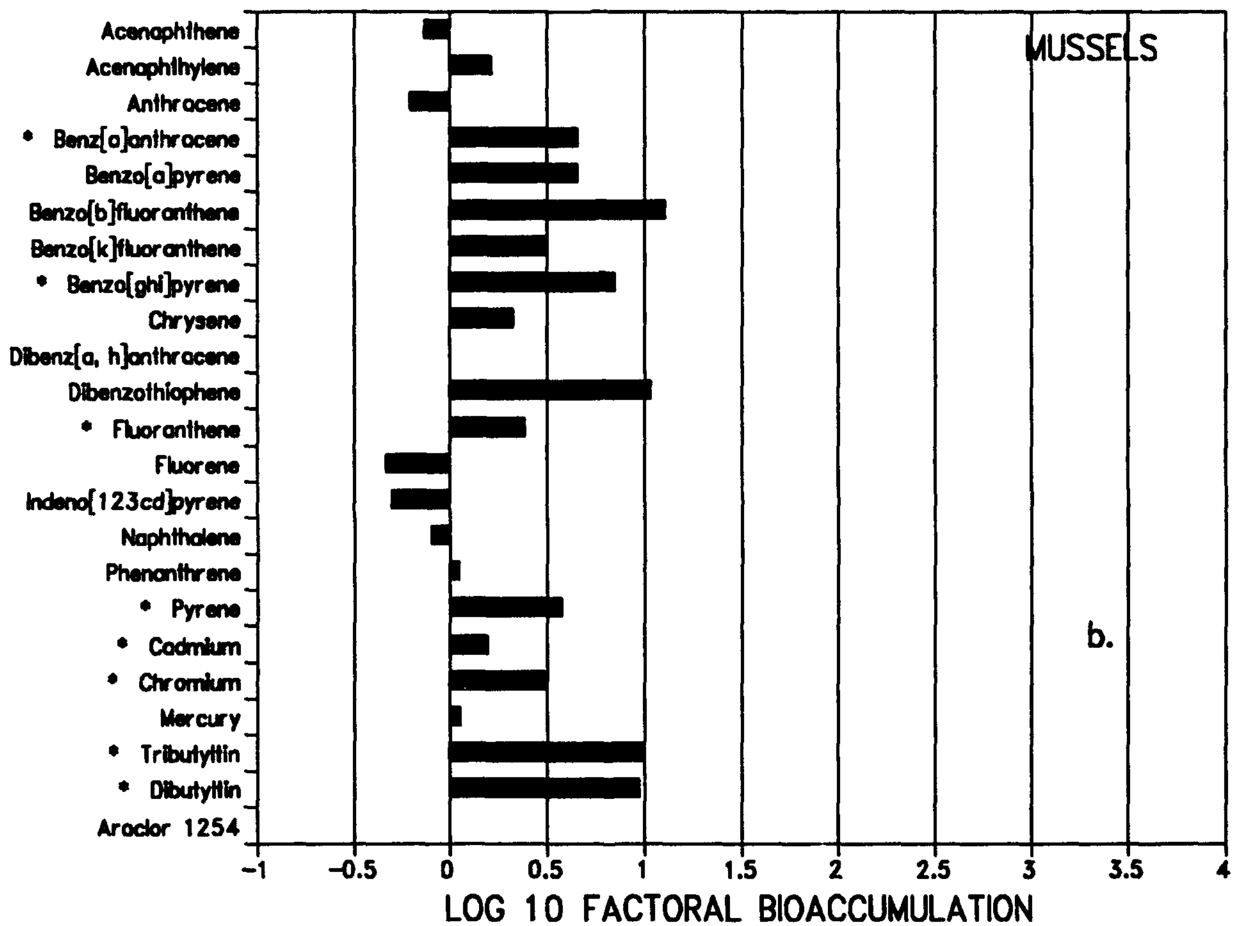

Figure B27. Bioaccumulation in mussels exposed to Reference S50 for 28 days. Log_{10}([exposed]/[background])

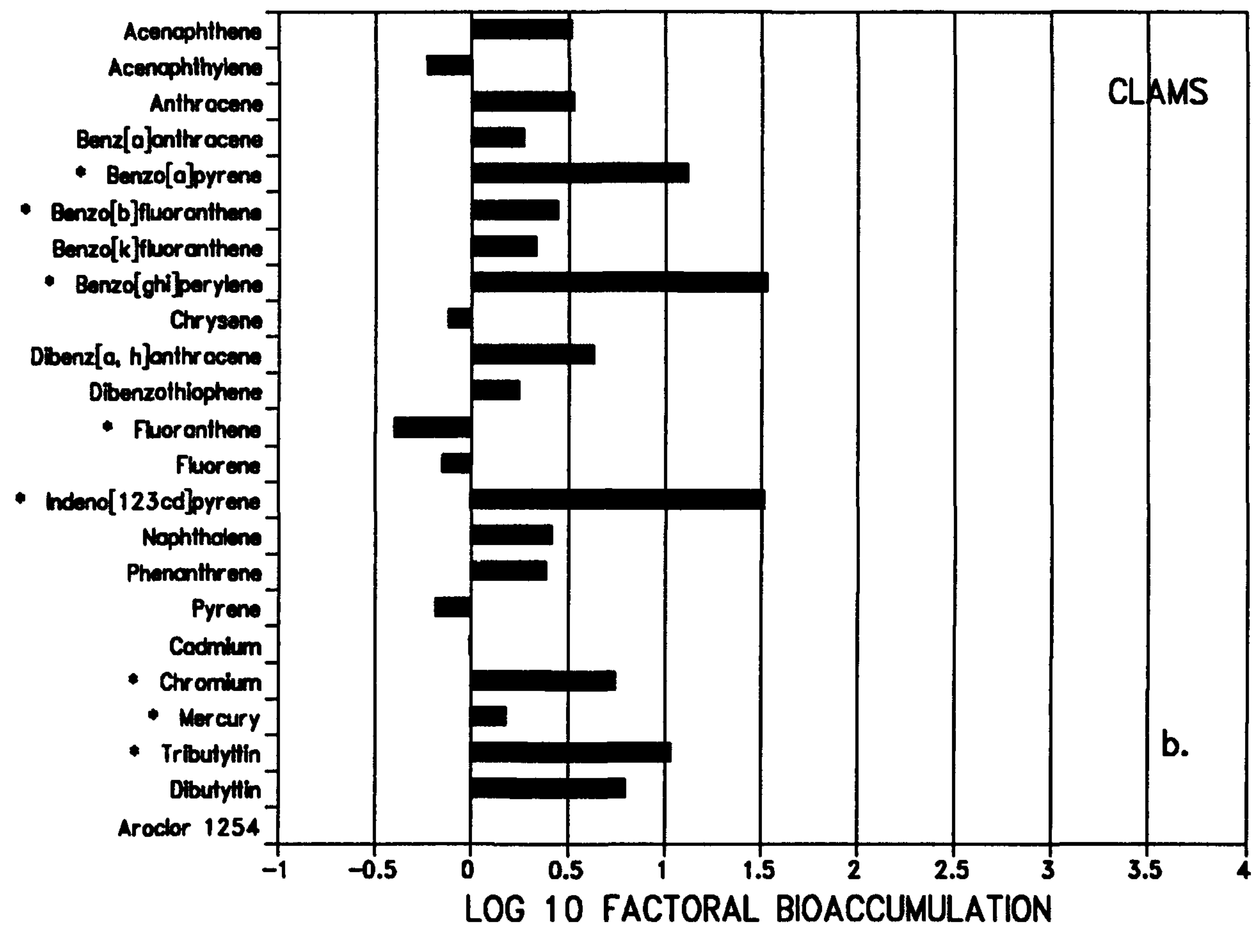

Figure B28. Bioaccumulation in clams exposed to Reference BS for 28 days. Log_{10}([exposed]/[background])

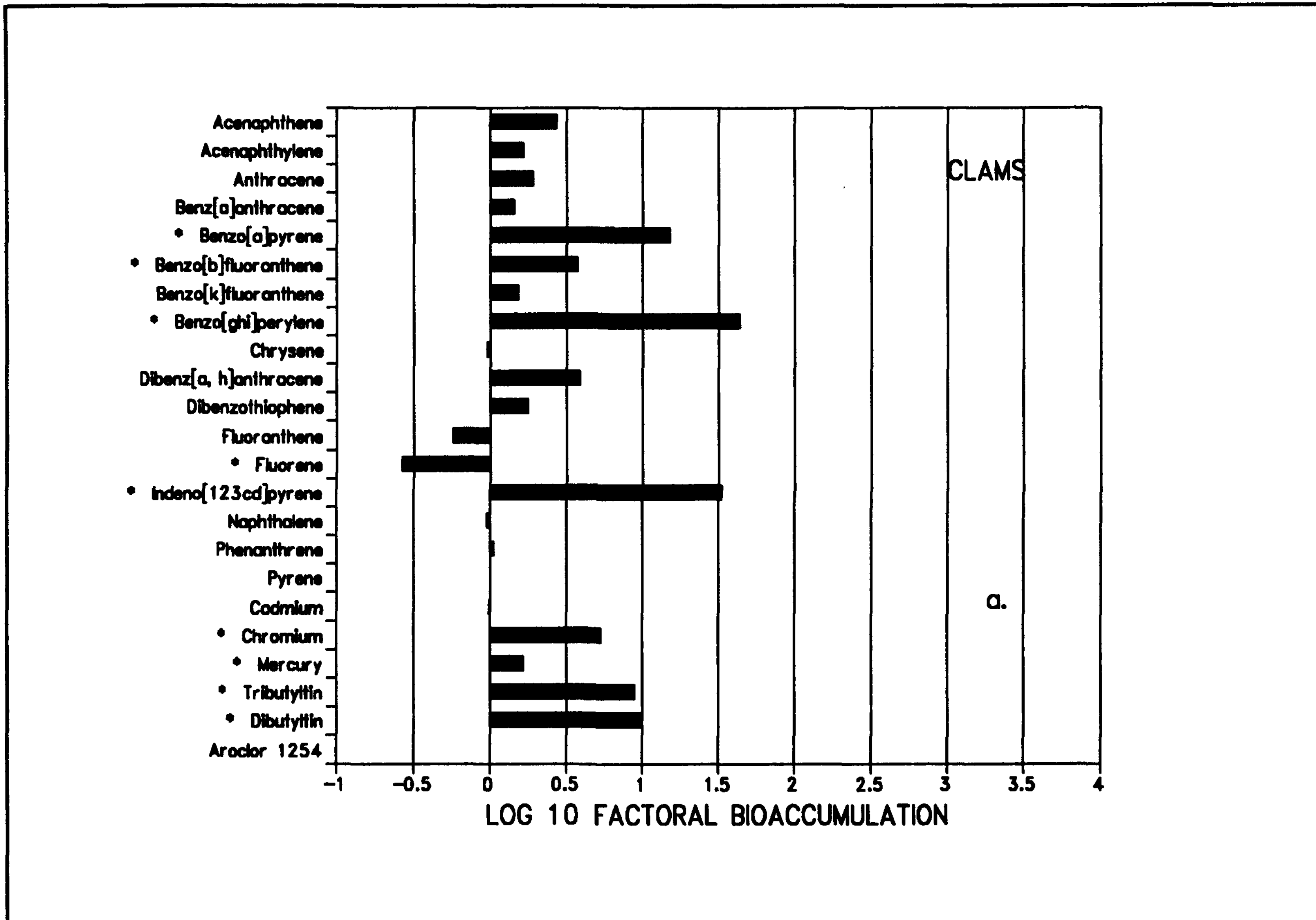

Figure B29. Bioaccumulation in clams exposed to Reference S50 for 28 days. Log_{10}([exposed]/[background])

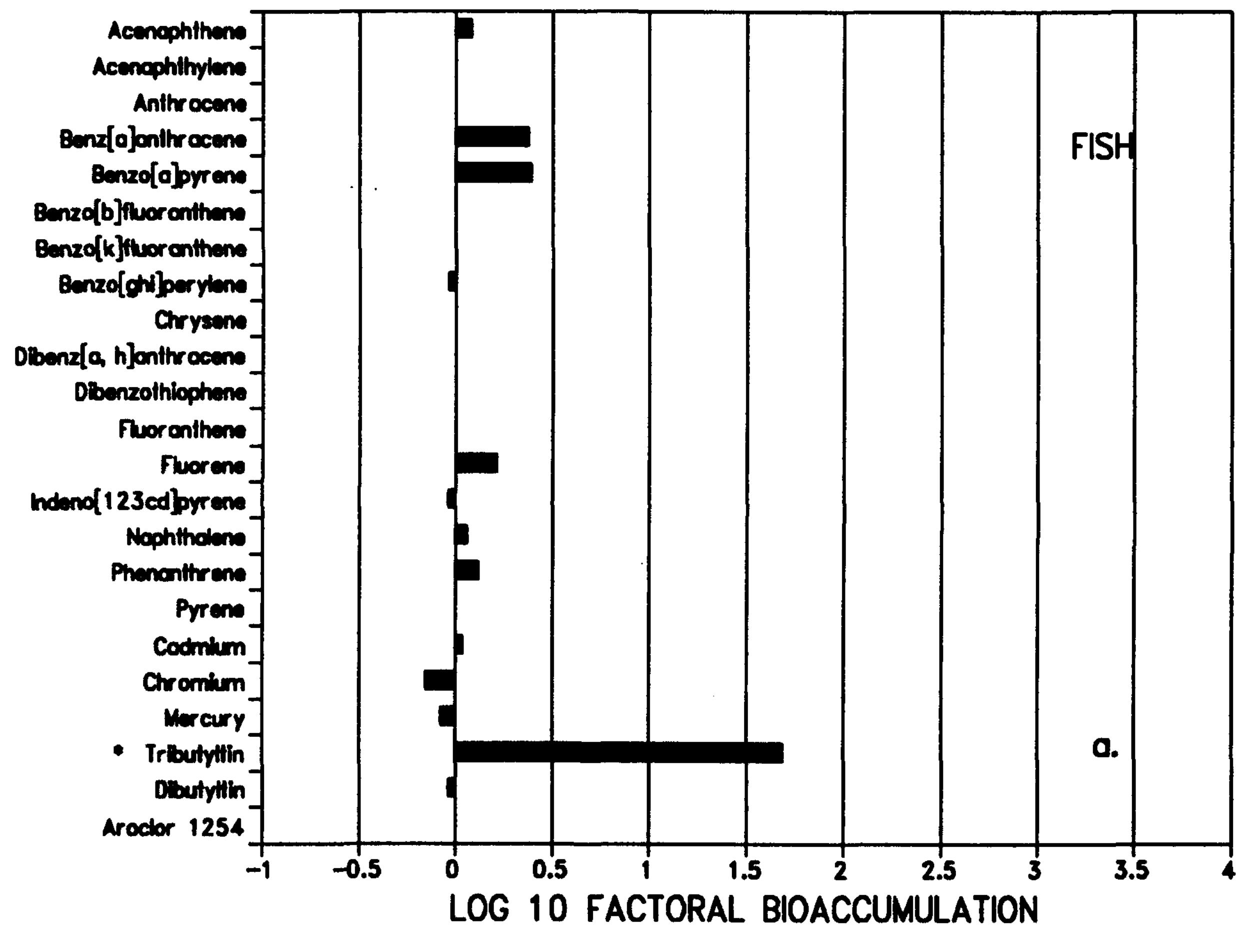

Figure B30. Bioaccumulation in fish exposed to Reference BS for 28 days. Log_{10}([exposed]/[background])

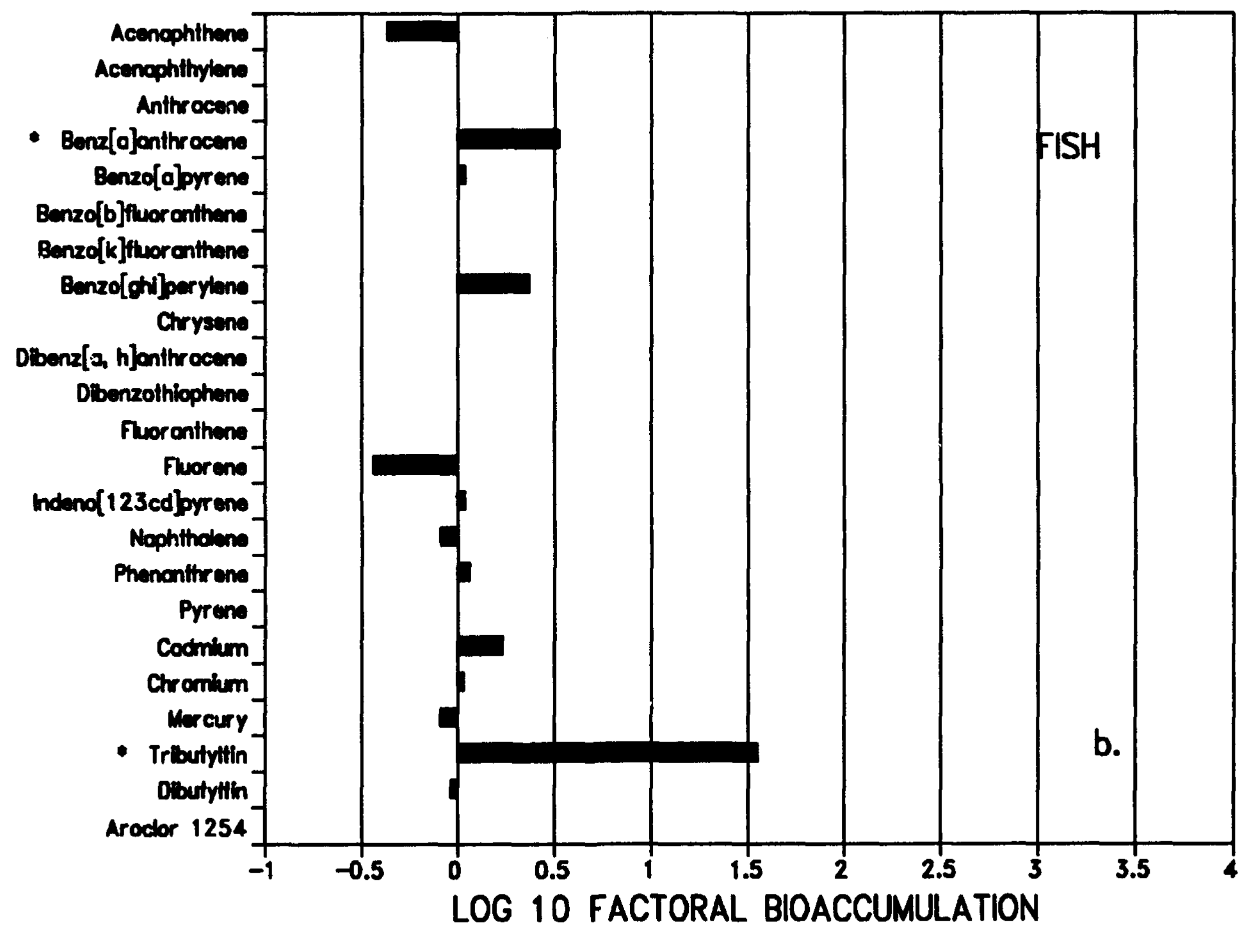

Figure B31. Bioaccumulation in fish exposed to Reference S50 for 28 days. Log_{10}([exposed]/[background])

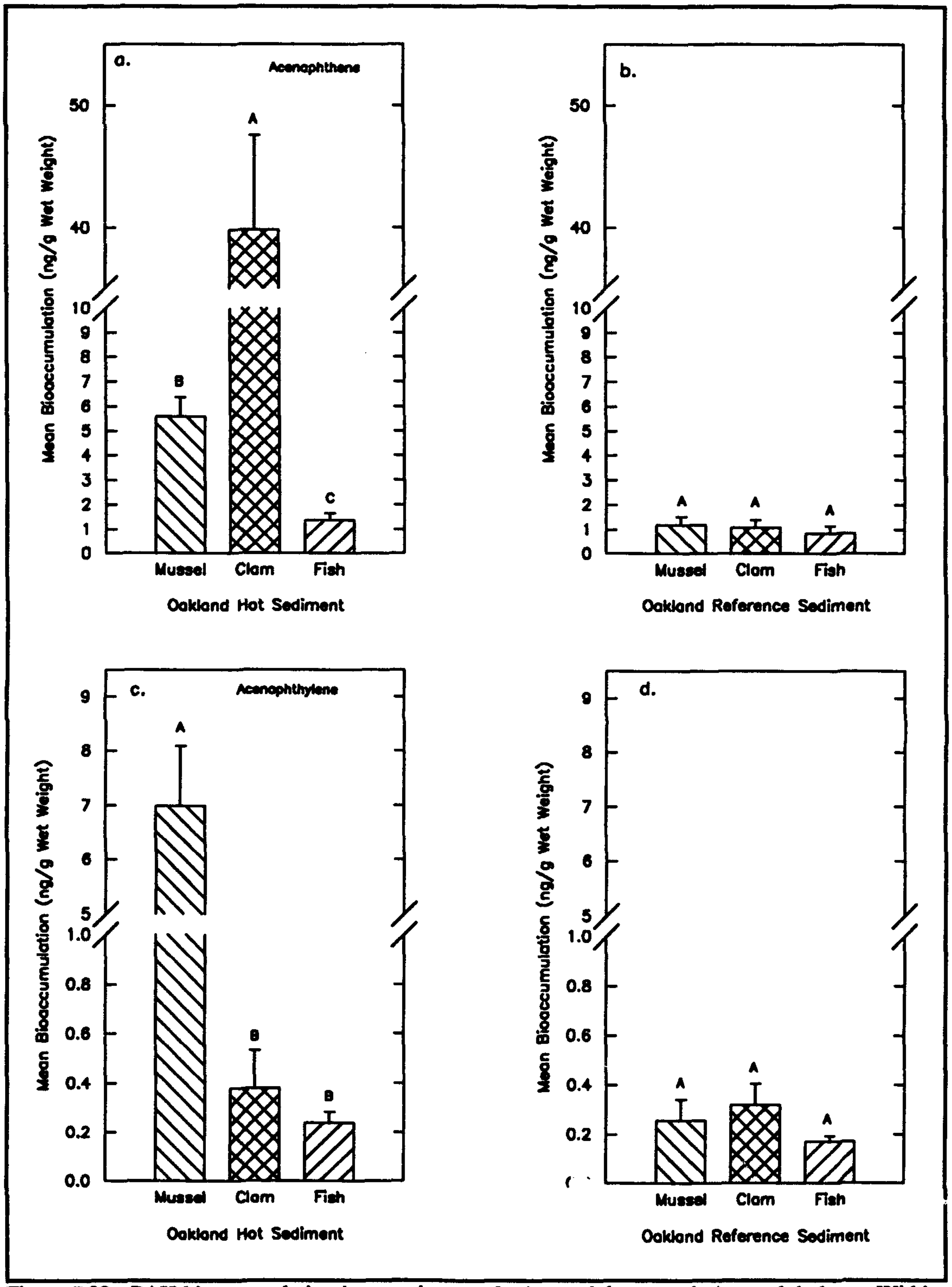

Figure B32. PAH bioaccumulation in organisms. a,b. Acenaphthene. c,d. Acenaphthylene. Within each box, bars with same letter are not significantly different ($P_{\alpha/2}$=0.025)

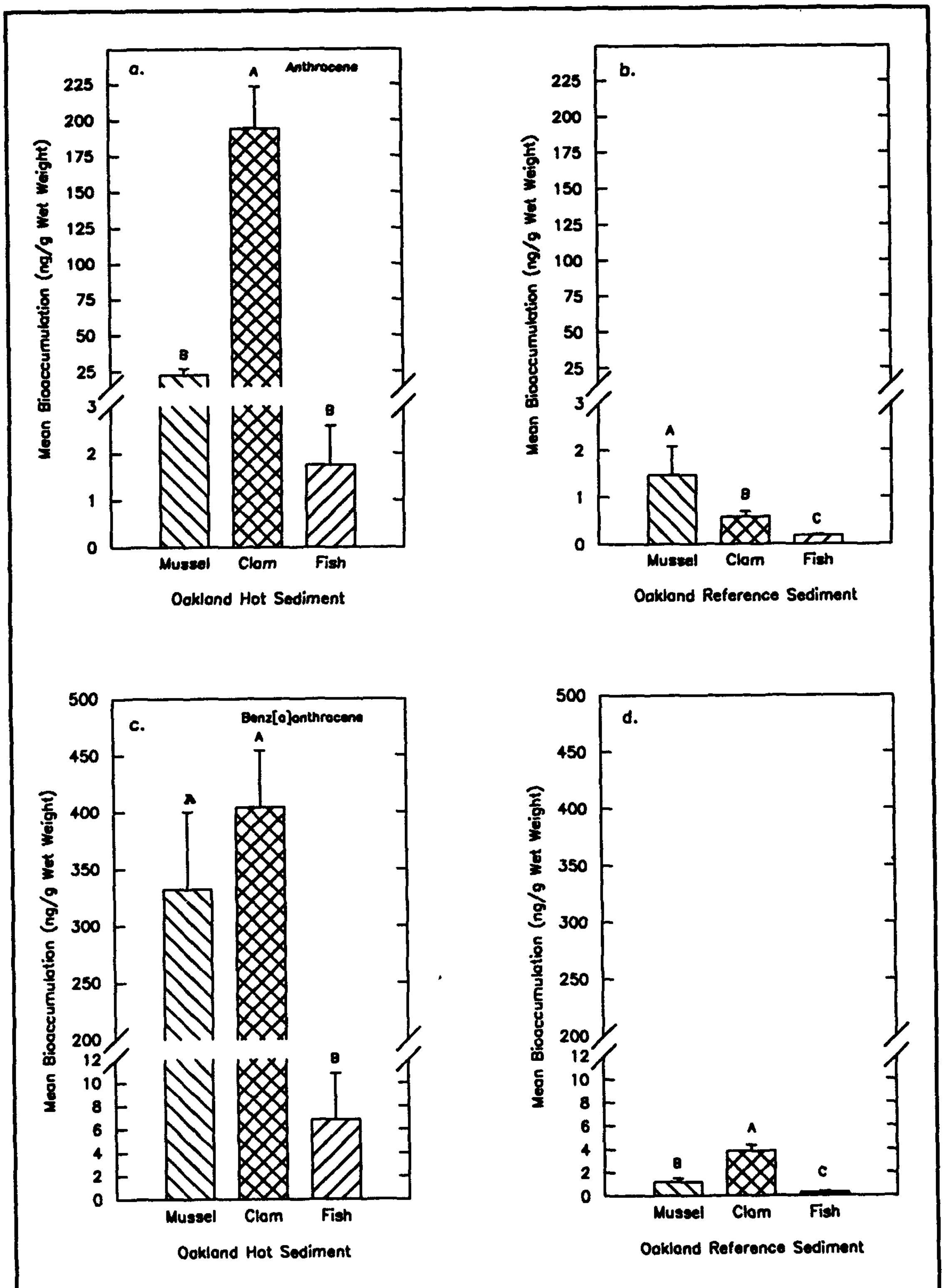

Figure B33. PAH bioaccumulation in organisms. a,b. Anthracene. c,d. Benz[a]anthracene

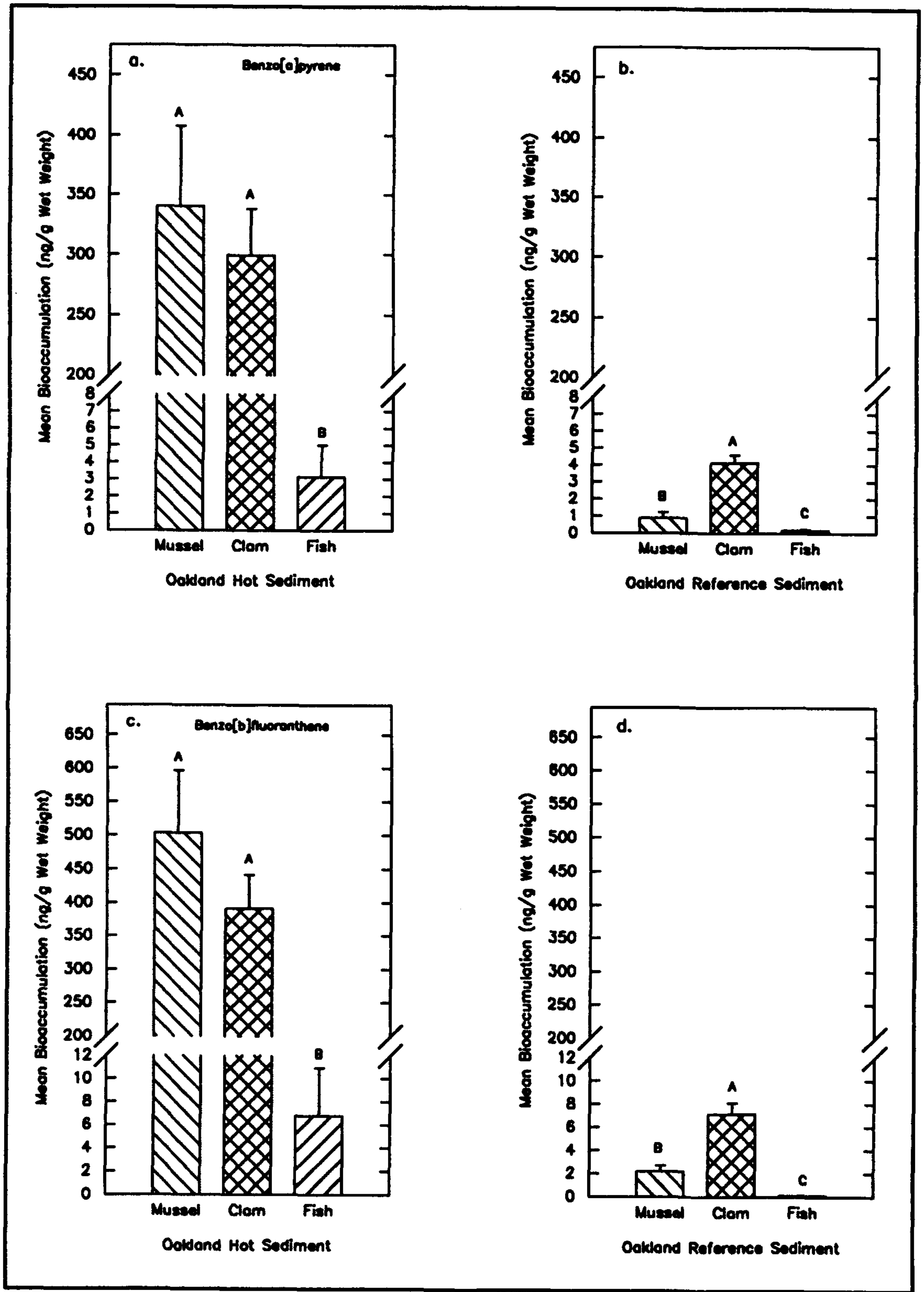

Figure B34. PAH bioaccumulation in organisms. a,b. Benzo[a]pyrene. c,d. Benzo[b]fluoranthene

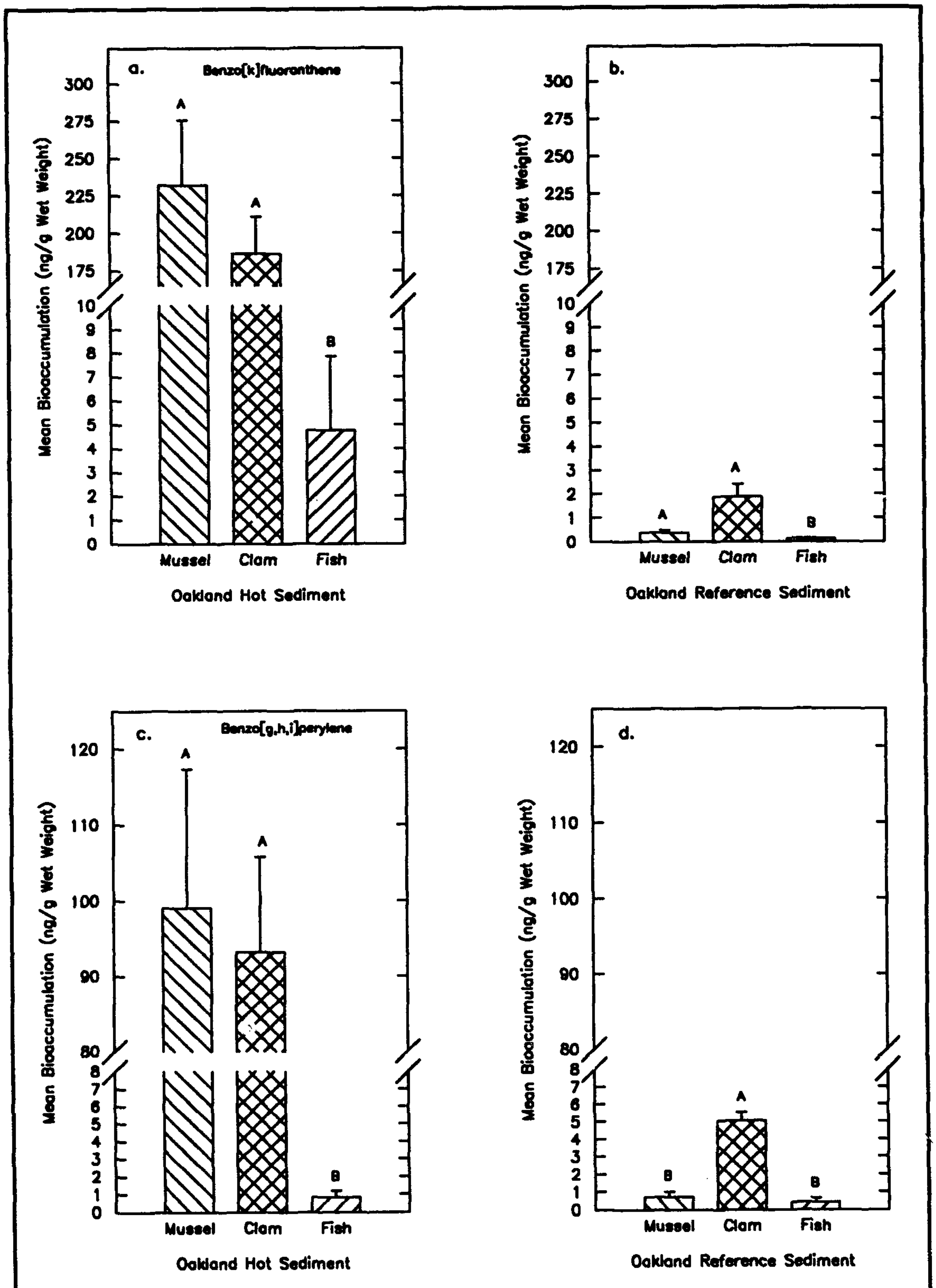

Figure B35. PAH bioaccumulation in organisms. a,b. Benzo[k]fluoranthene. c,d. Benzo[g,h,i]perylene

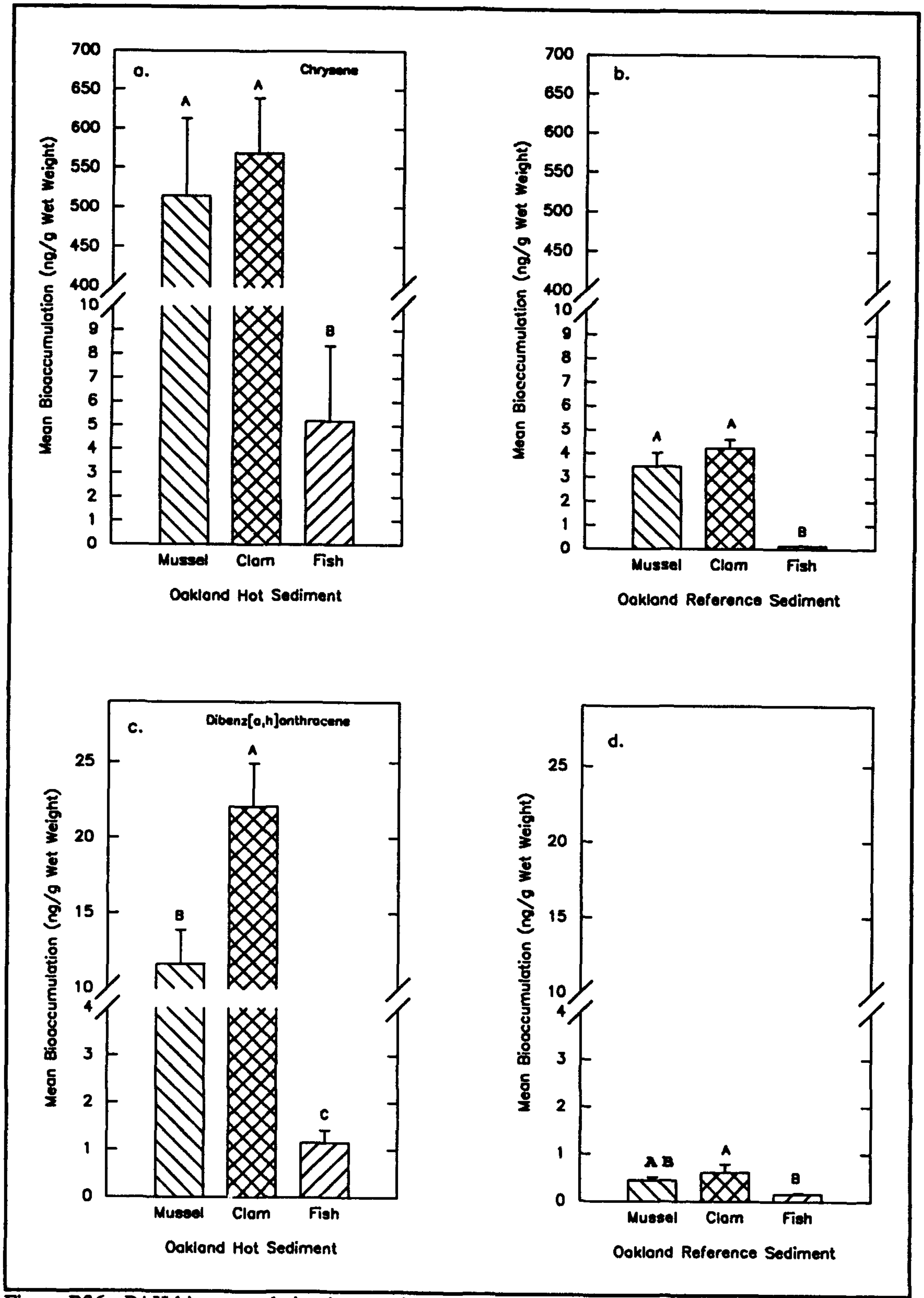

Figure B36. PAH bioaccumulation in organisms. a,b. Chrysene. c,d. Dibenz[a,h]anthracene

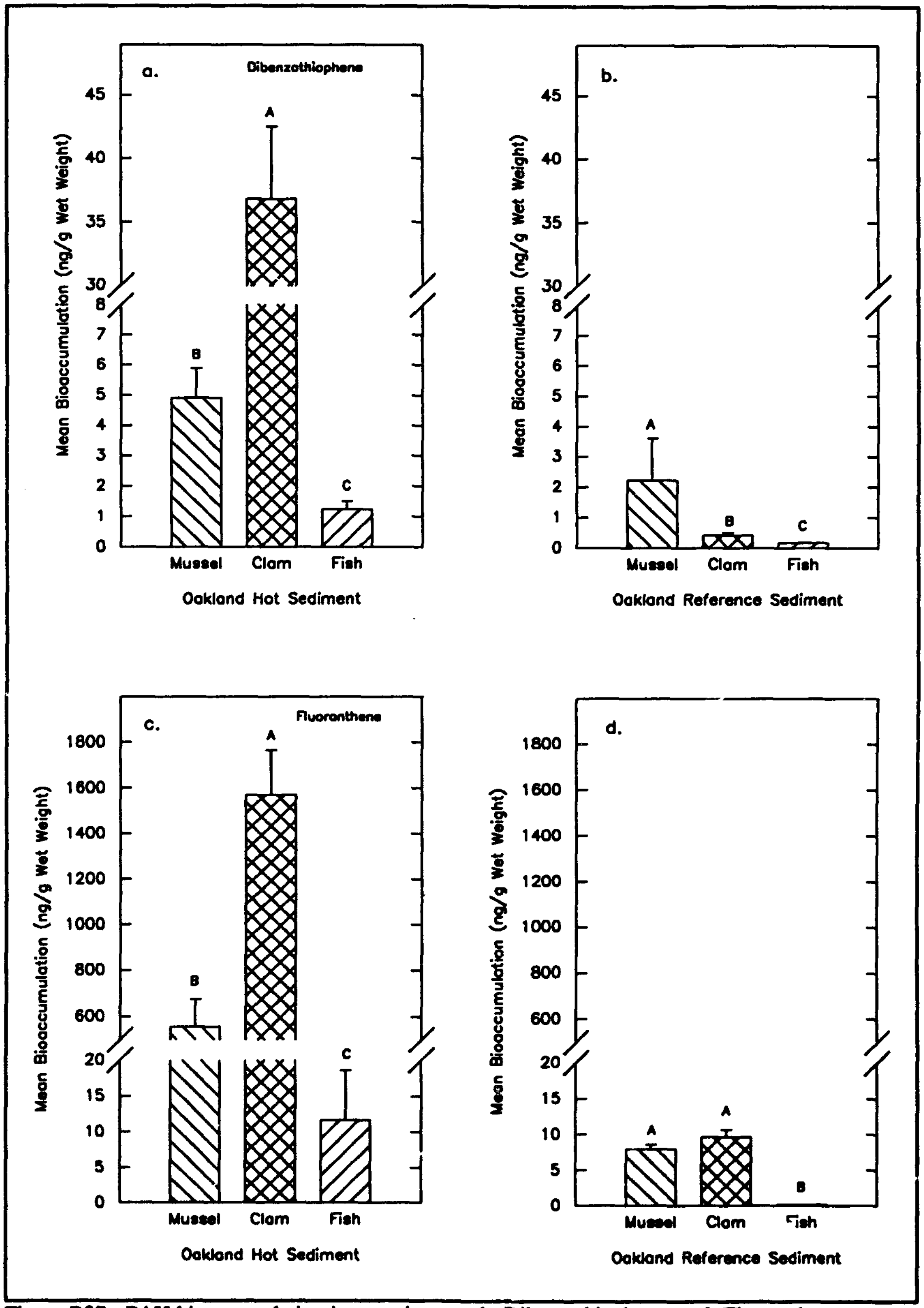

Figure B37. PAH bioaccumulation in organisms. a,b. Dibenzothiophene. c,d. Fluoranthene

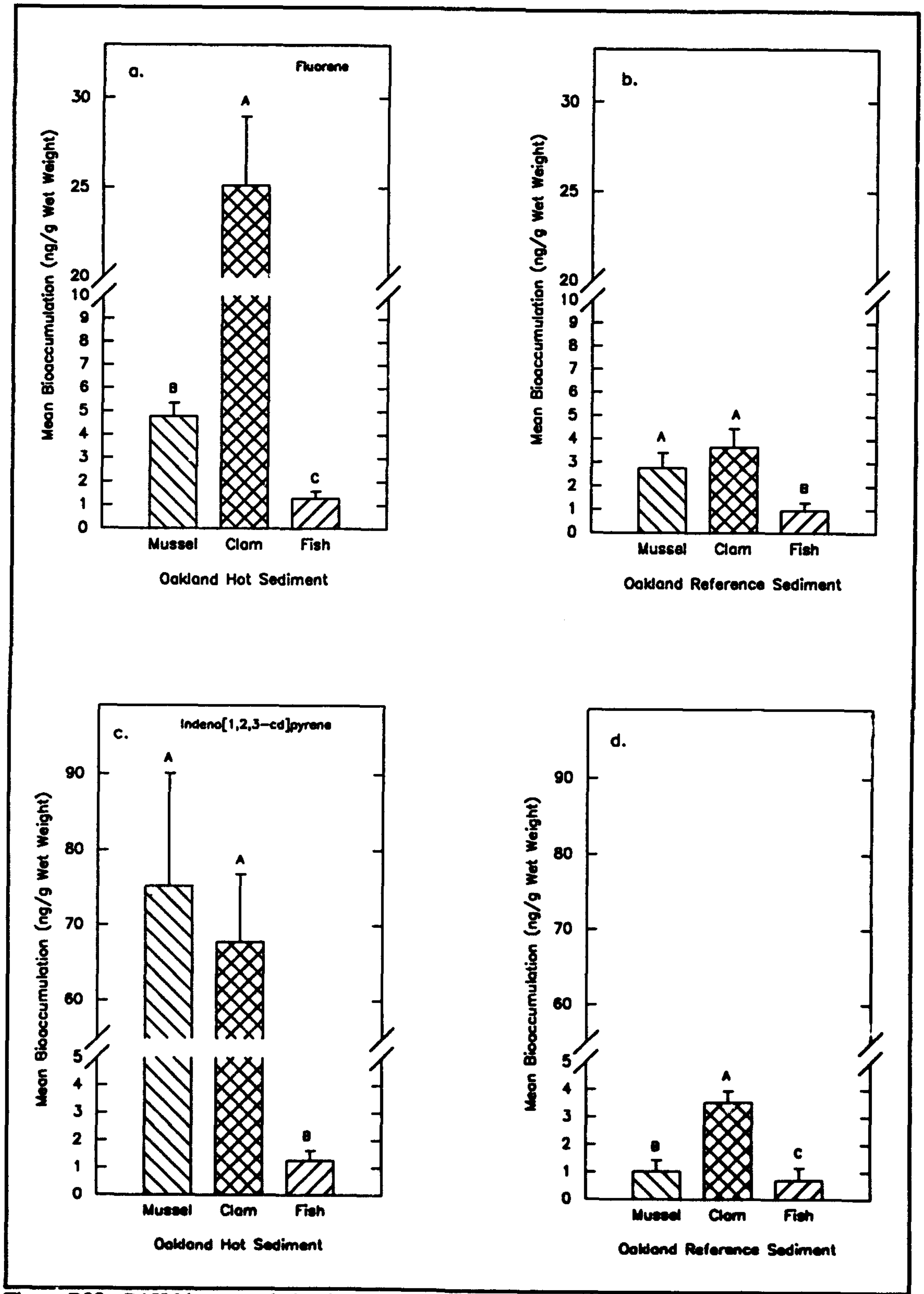

Figure B38. PAH bioaccumulation in organisms. a,b. Fluorene. c,d. Indeno[1,2,3-cd]pyrene

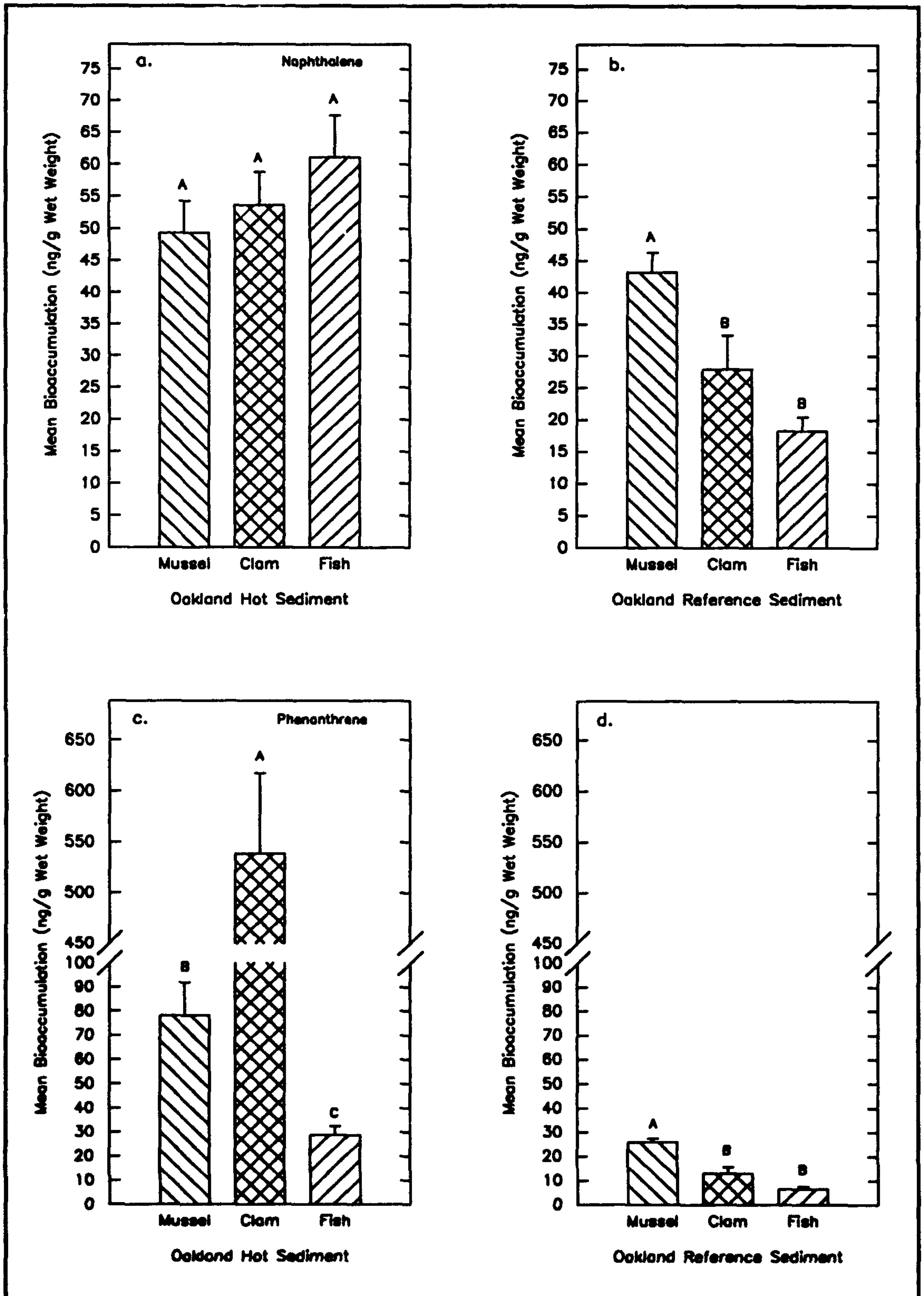

Figure B39. PAH bioaccumulation in organisms. a,b. Naphthalene. c,d. Phenanthrene

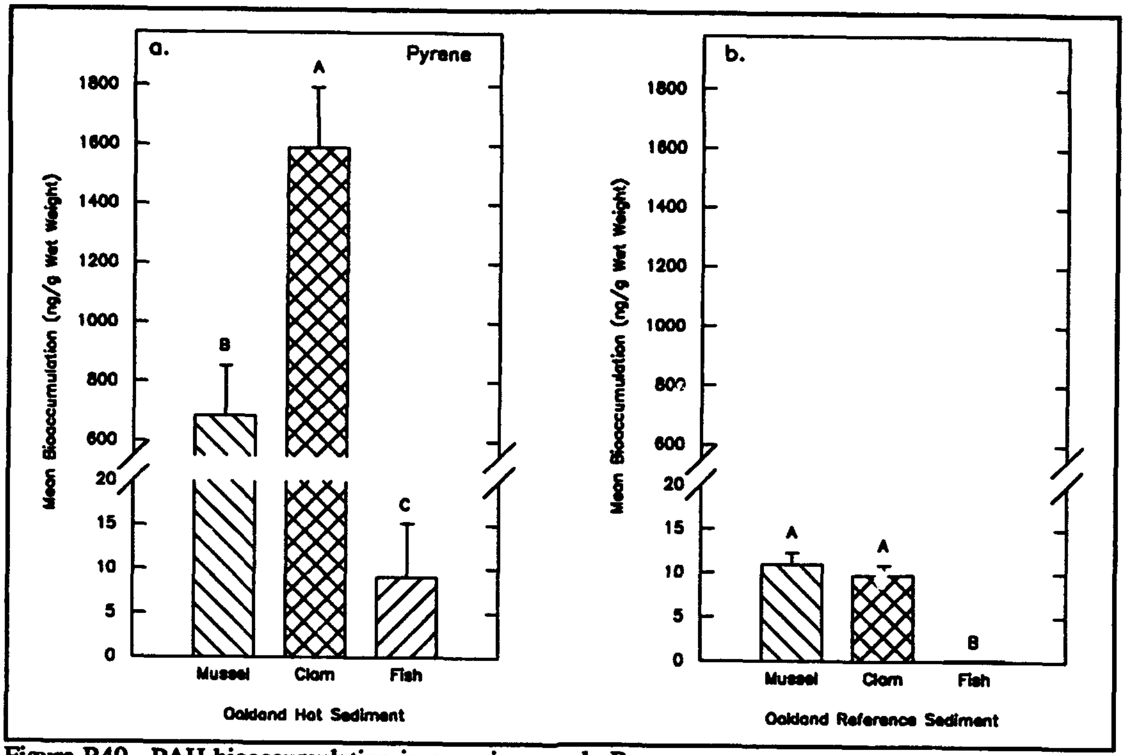

Figure B40. PAH bioaccumulation in organisms. a,b. Pyrene

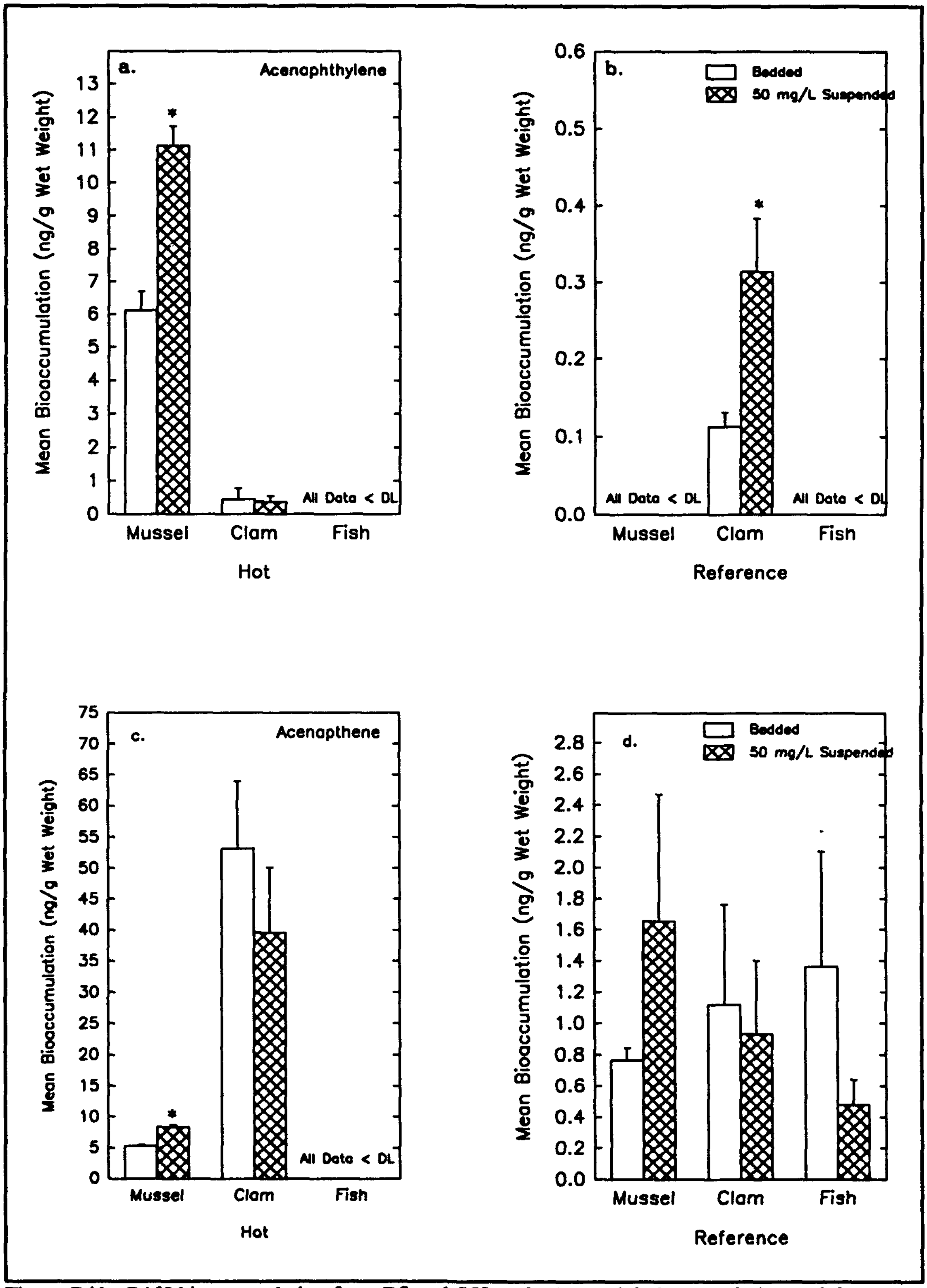

Figure B41. PAH bioaccumulation from BS and S50. a,b. Acenaphthylene. c,d. Acenaphthene.
* BS significantly different from S50 ($P_{\alpha/2} \leq 0.025$)

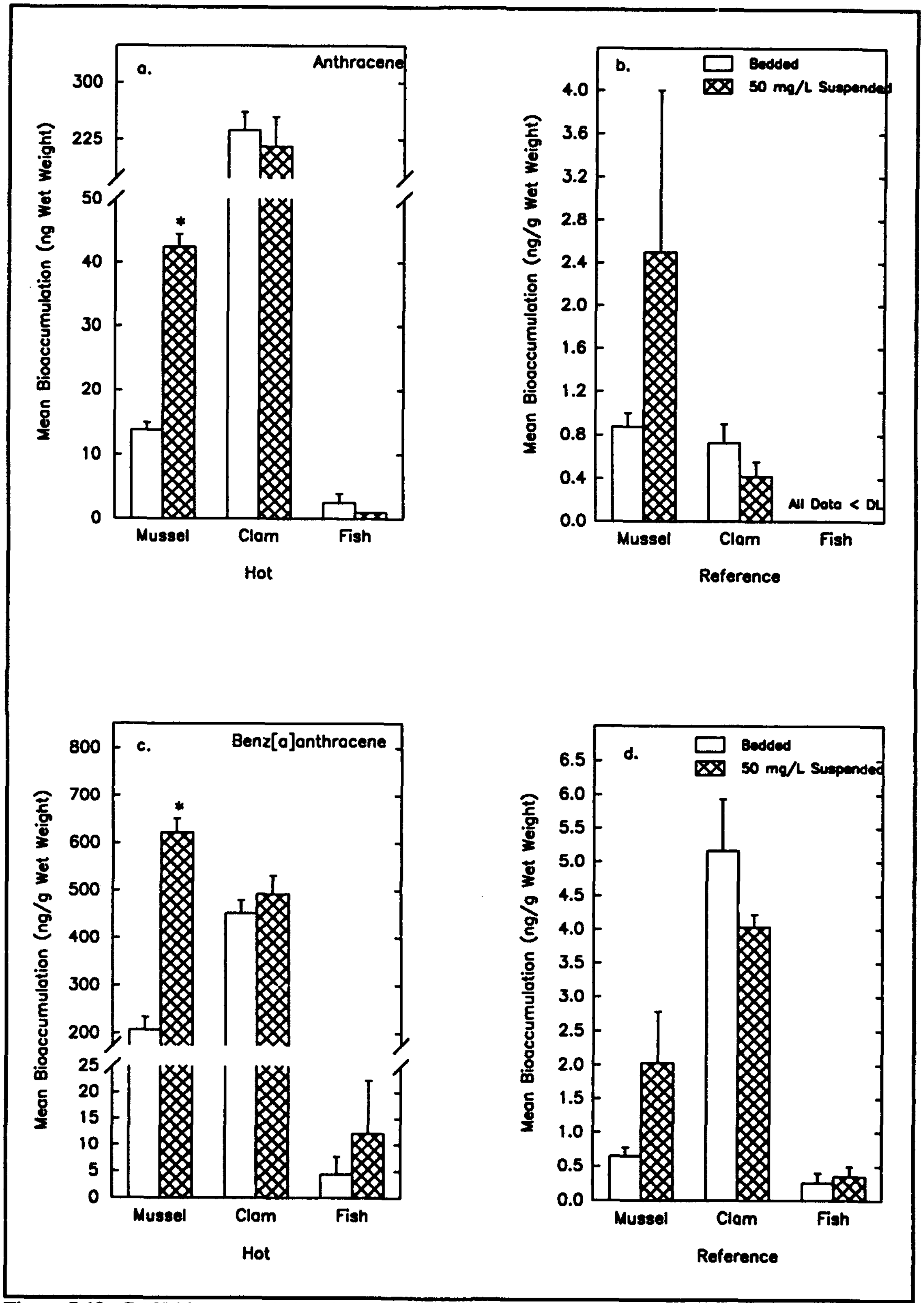

Figure B42. PAH bioaccumulation from BS and S50. a,b. Anthracene. c,d. Benz[a]anthracene

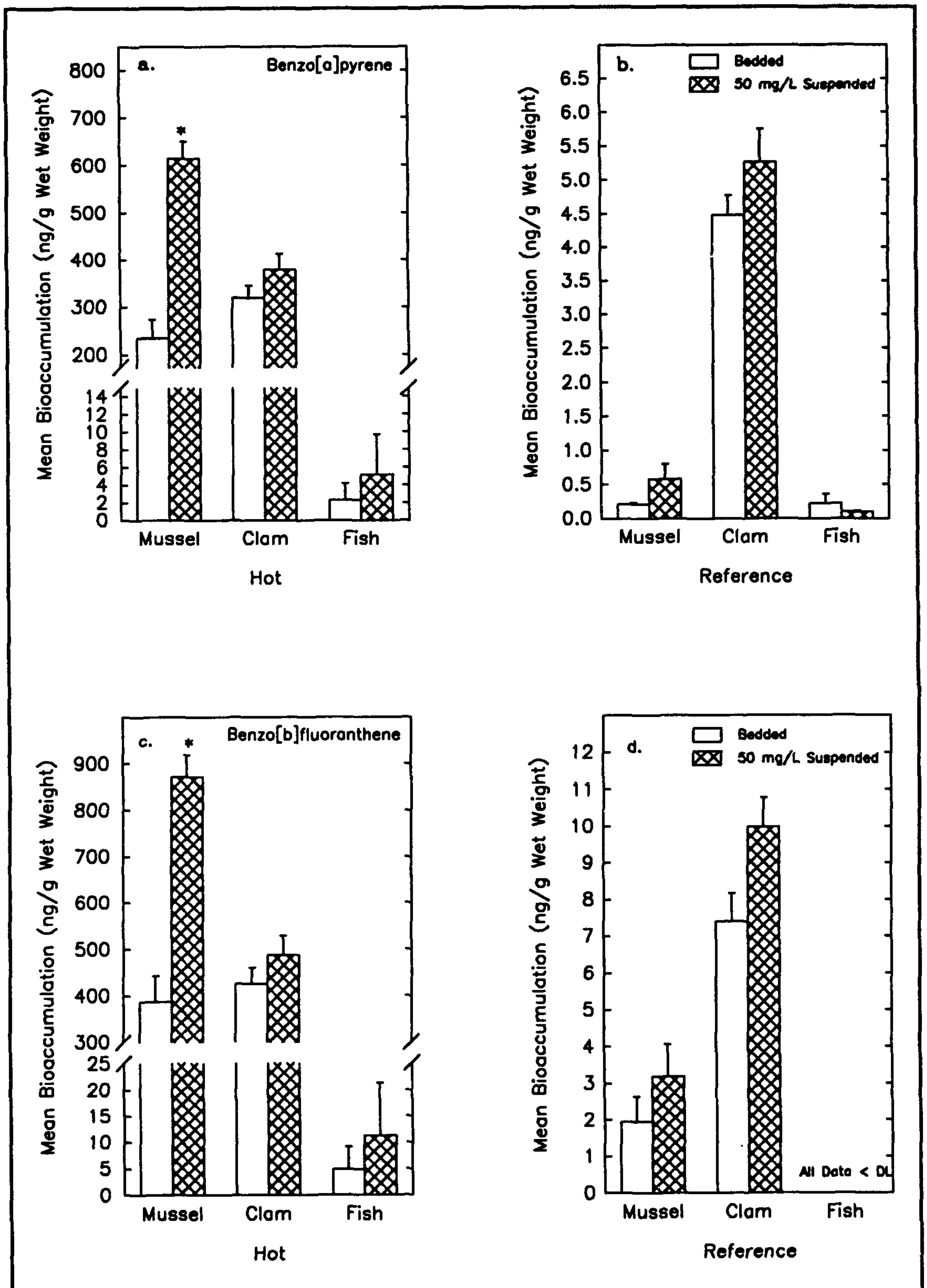

Figure B43. PAH bioaccumulation from BS and S50. a,b. Benzo[a]pyrene. c,d. Benzo[b]fluoranthene

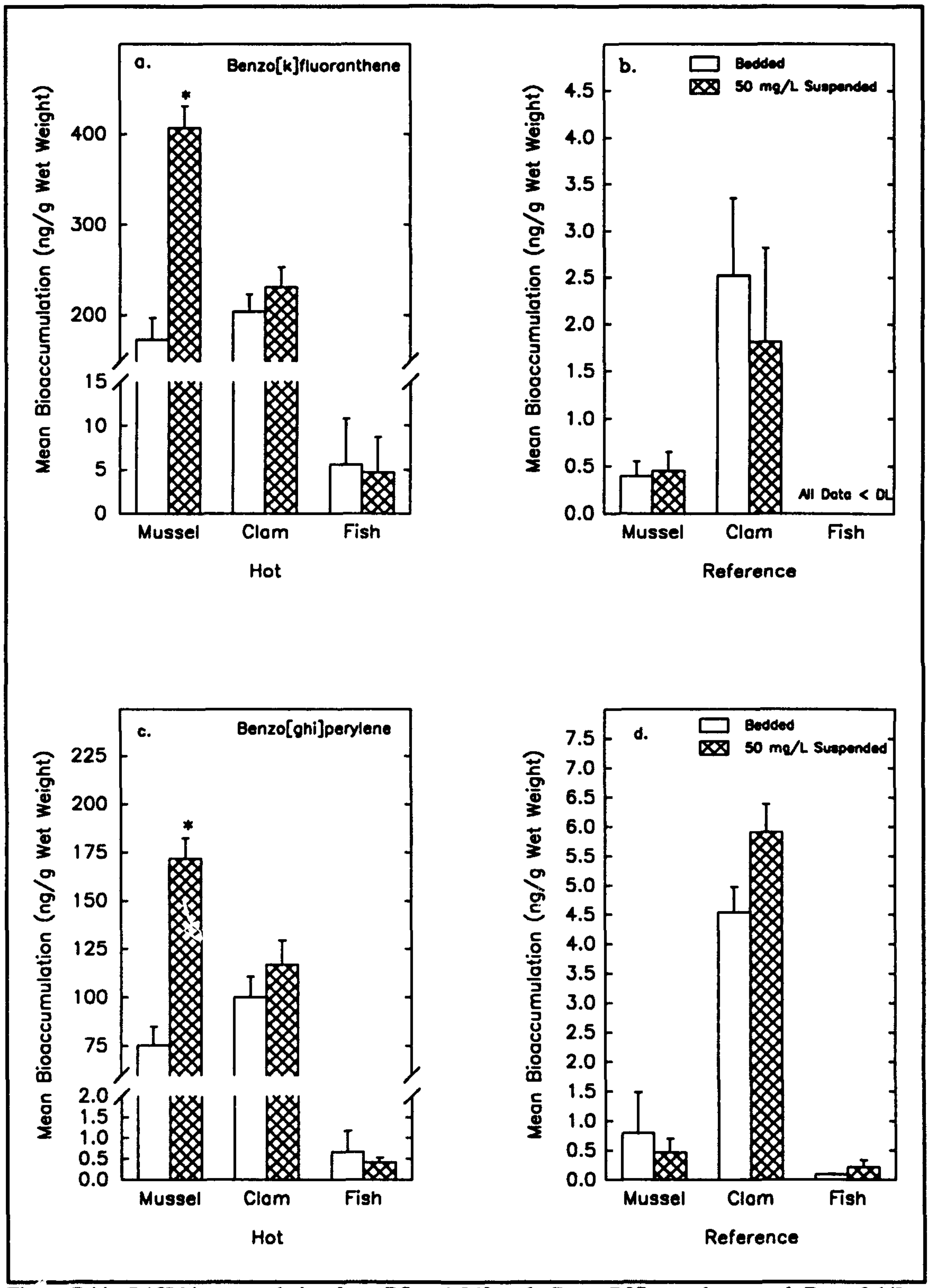

Figure B44. PAH bioaccumulation from BS and S50. a,b. Benzo[k]fluoranthene. c,d. Benzo[ghi]-perylene

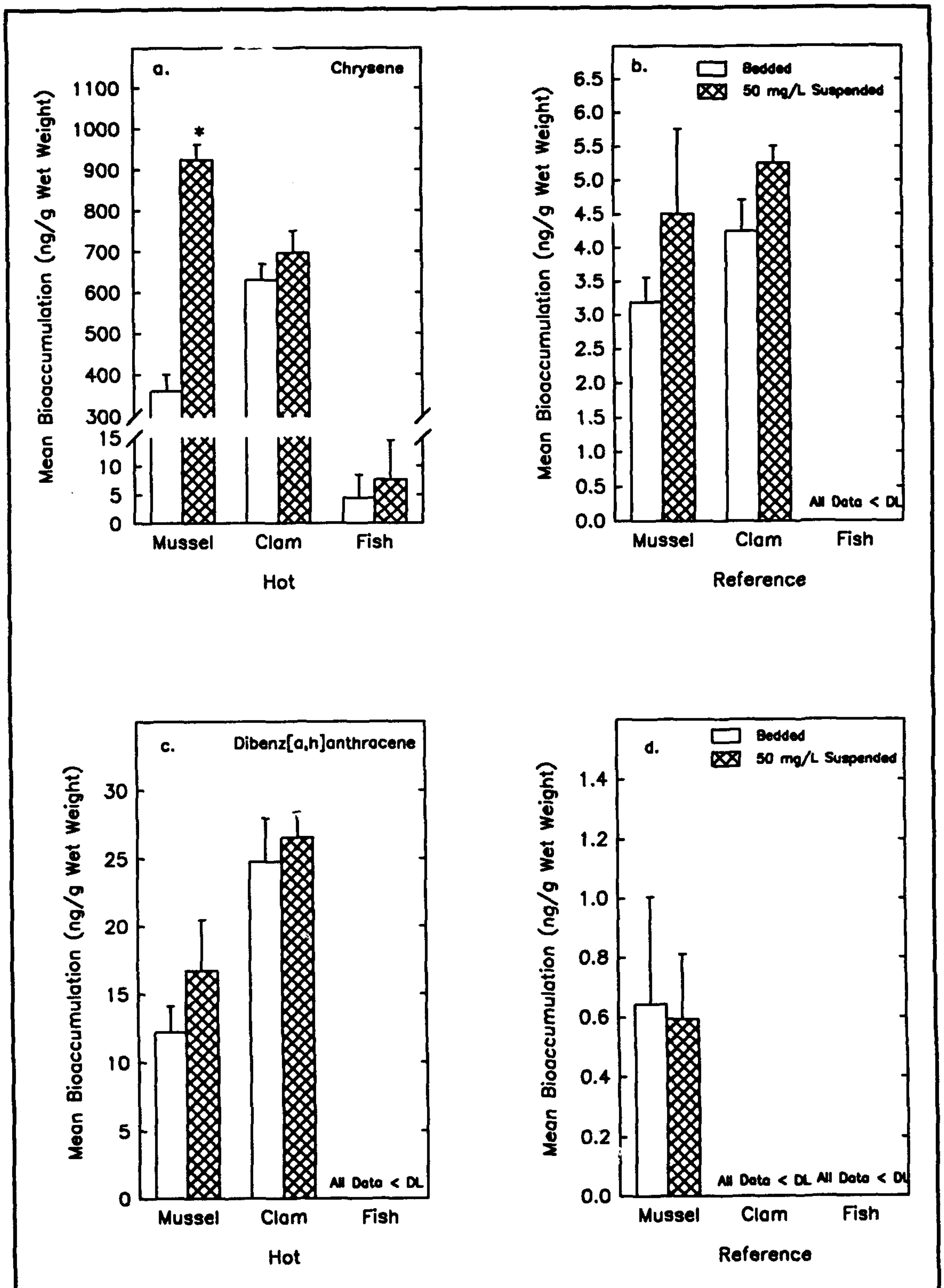

Figure B45. PAH bioaccumulation from BS and S50. a,b. Chrysene. c,d. Dibenz[a,h]anthracene

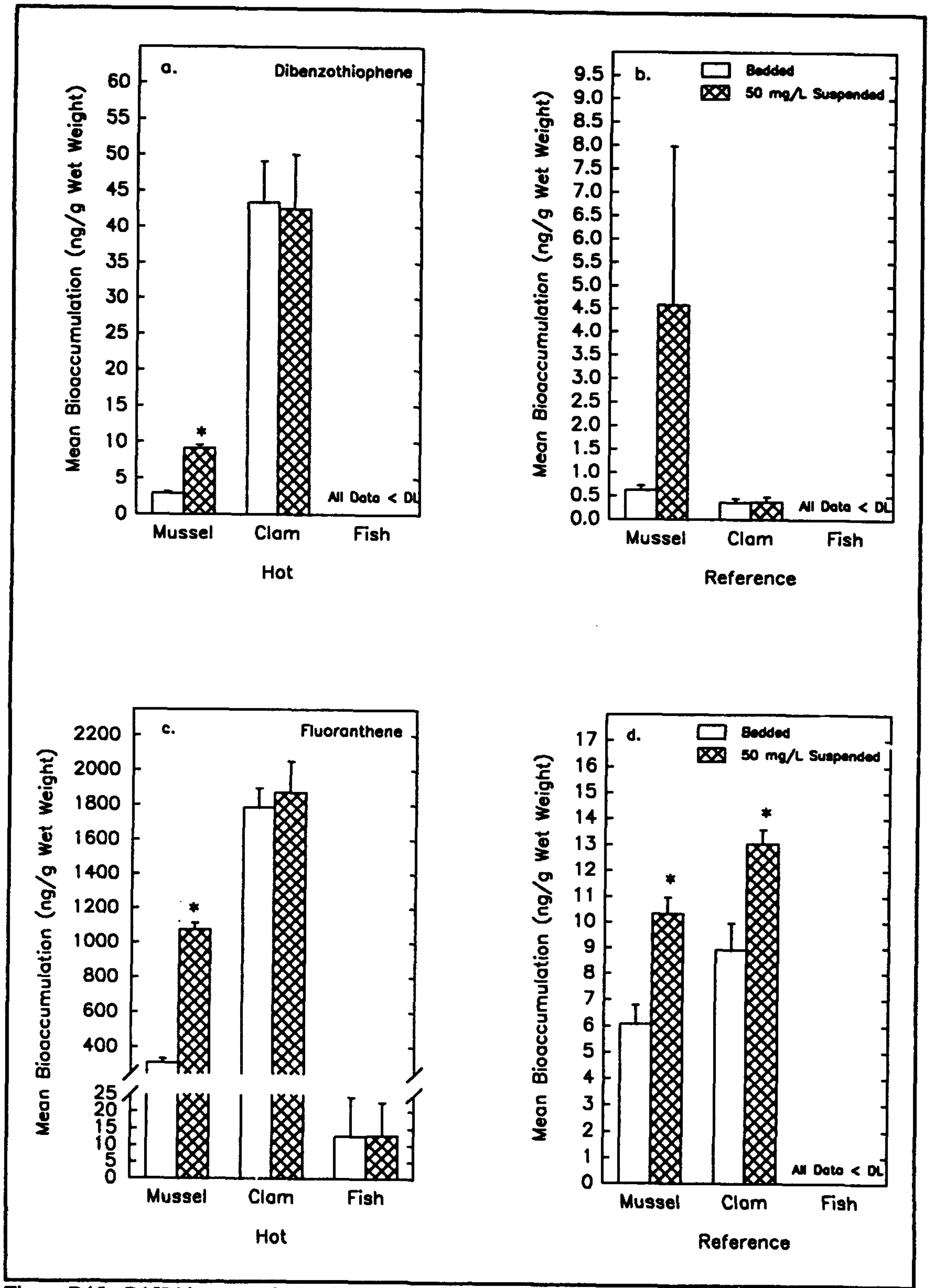

Figure B46. PAH bioaccumulation from BS and S50. a,b. Dibenzothiophene. c,d. Fluoranthene

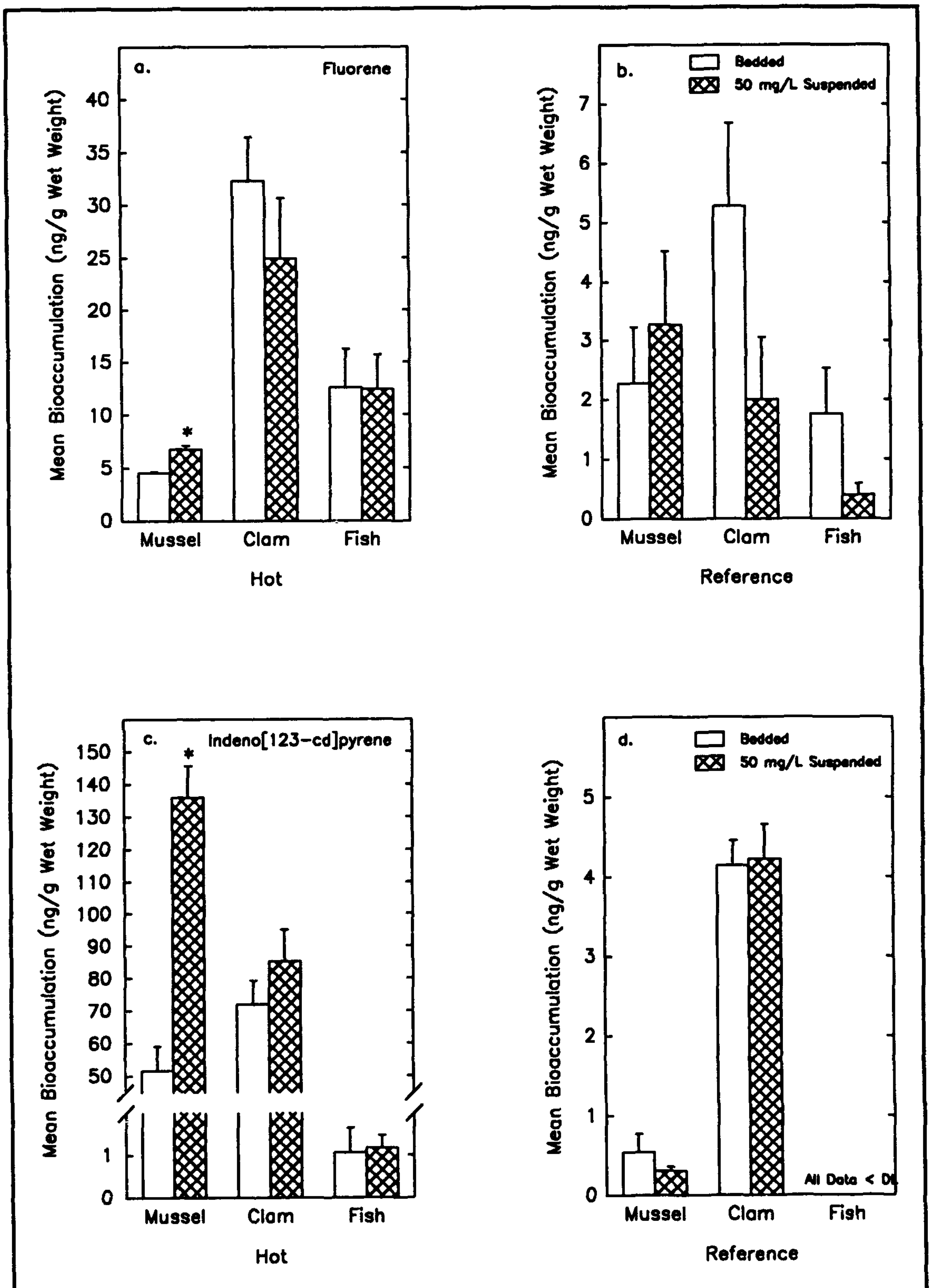

Figure B47. PAH bioaccumulation from BS and S50. a,b. Fluorene. c,d. Indeno[123-cd]pyrene

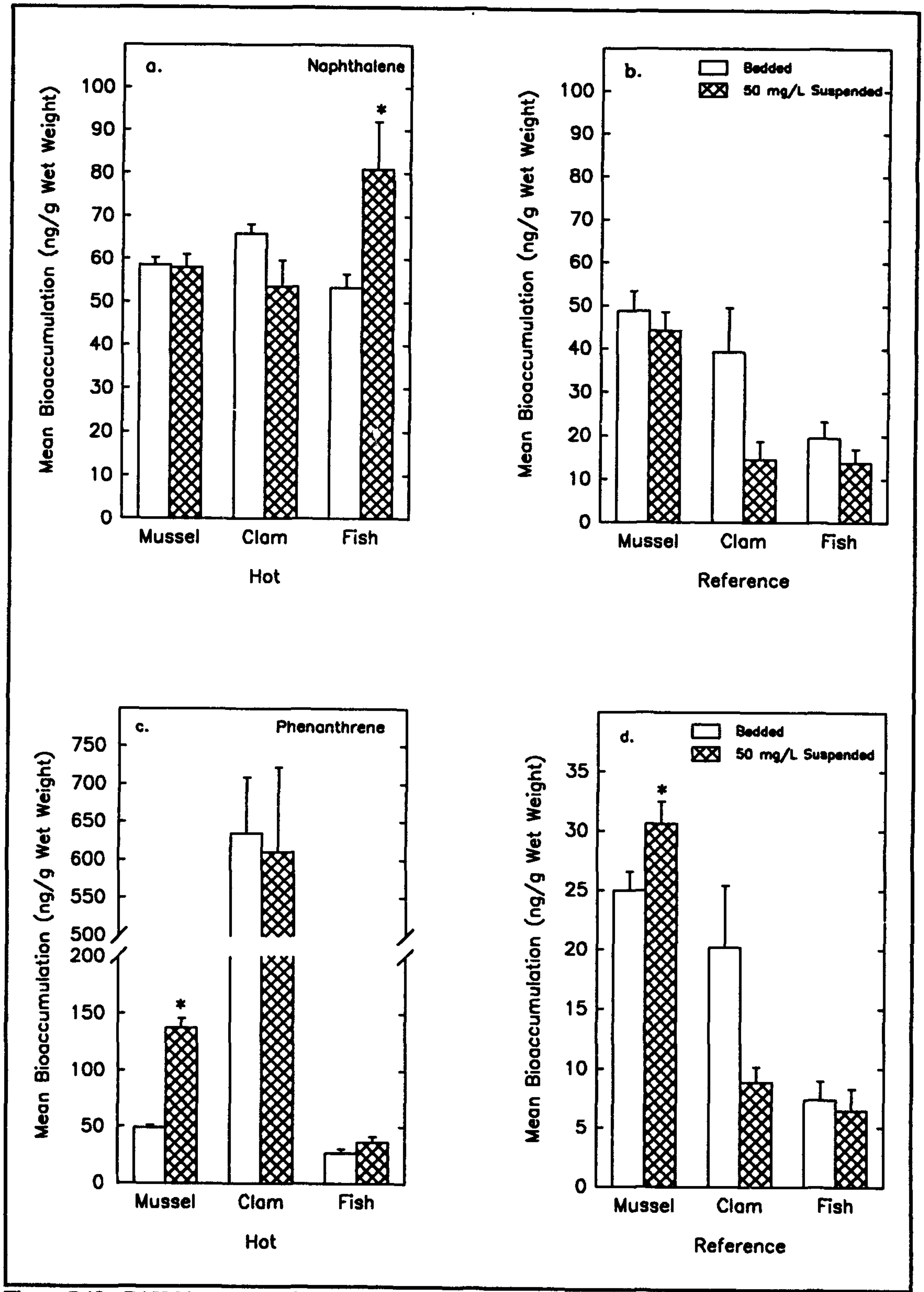

Figure B48. PAH bioaccumulation from BS and S50. a,b. Naphthalene. c,d. Phenanthrene

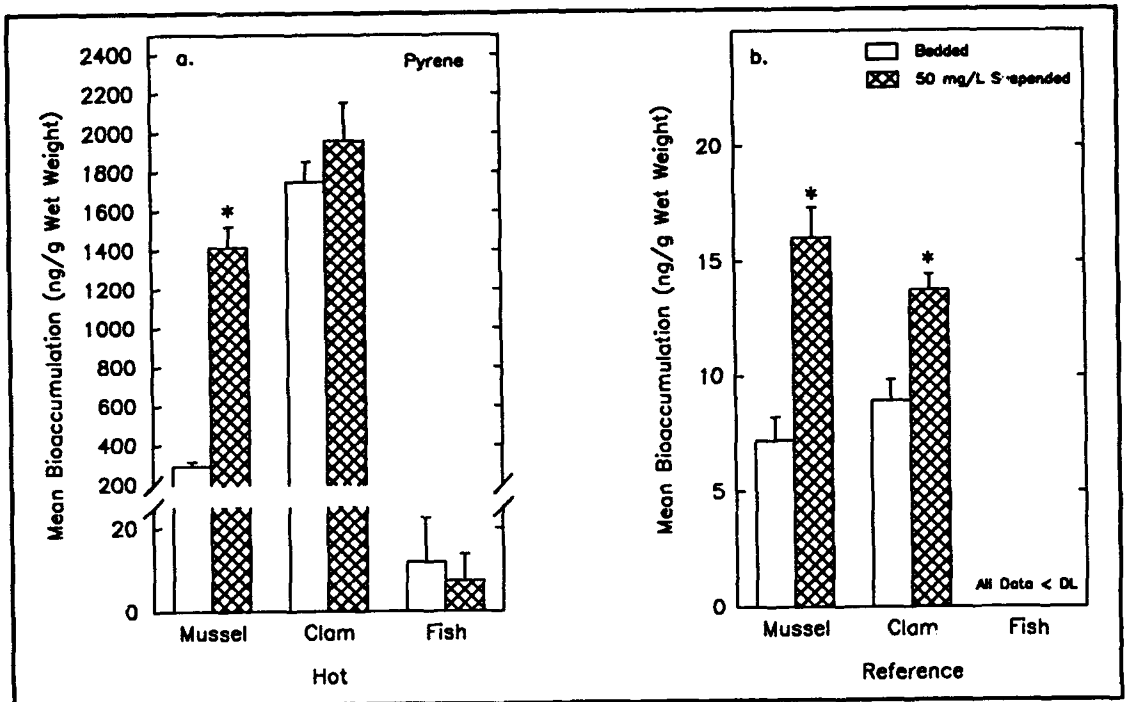

Figure B49. PAH bioaccumulation from BS and S50. a,b. Pyrene

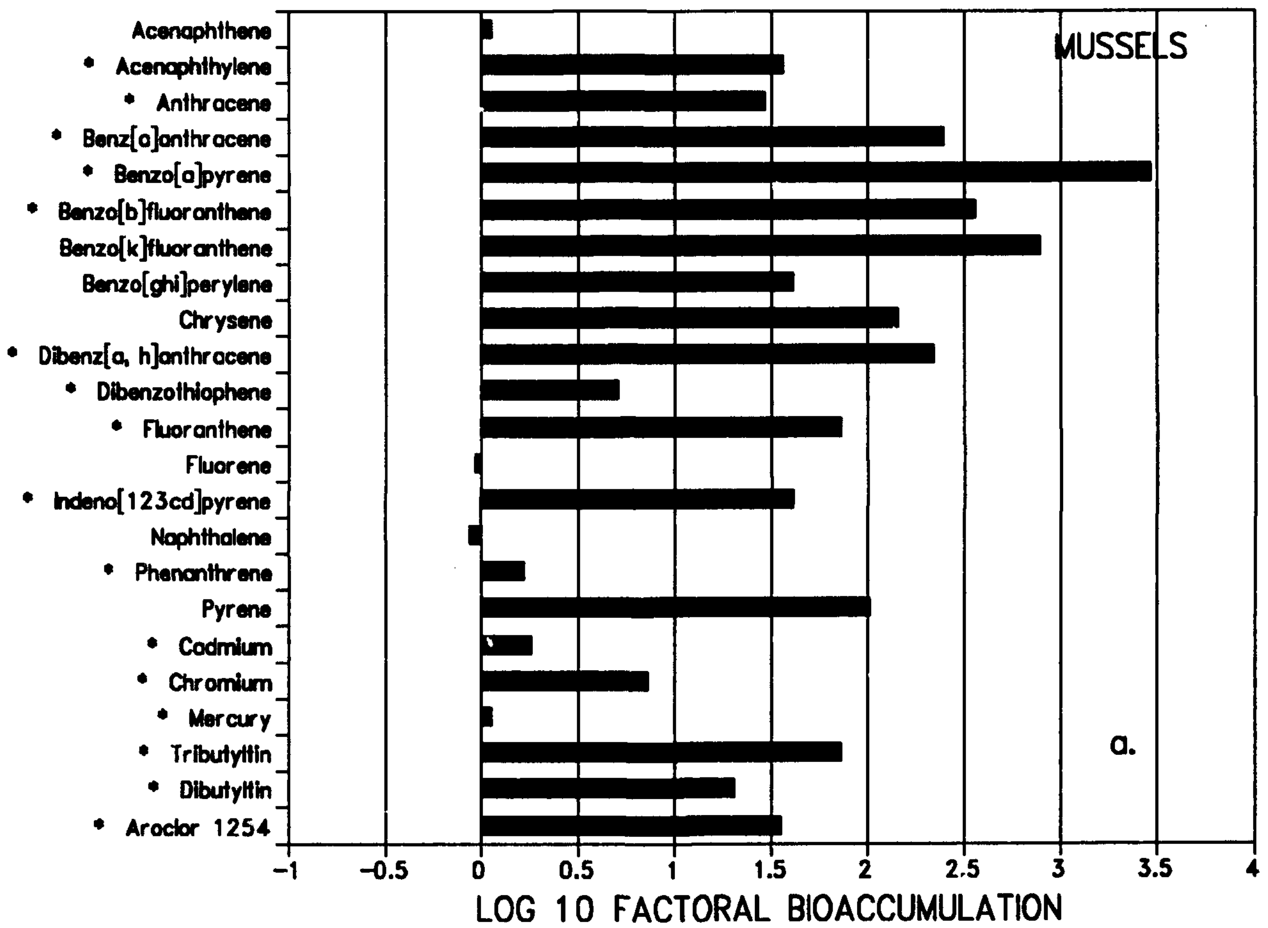

Figure B50. Bioaccumulation in mussels exposed to Hot BS for 28 days. Log_{10}([exposed]/[background]). * Exposed significantly different from background ($P_{\alpha/2} \leq 0.025$)

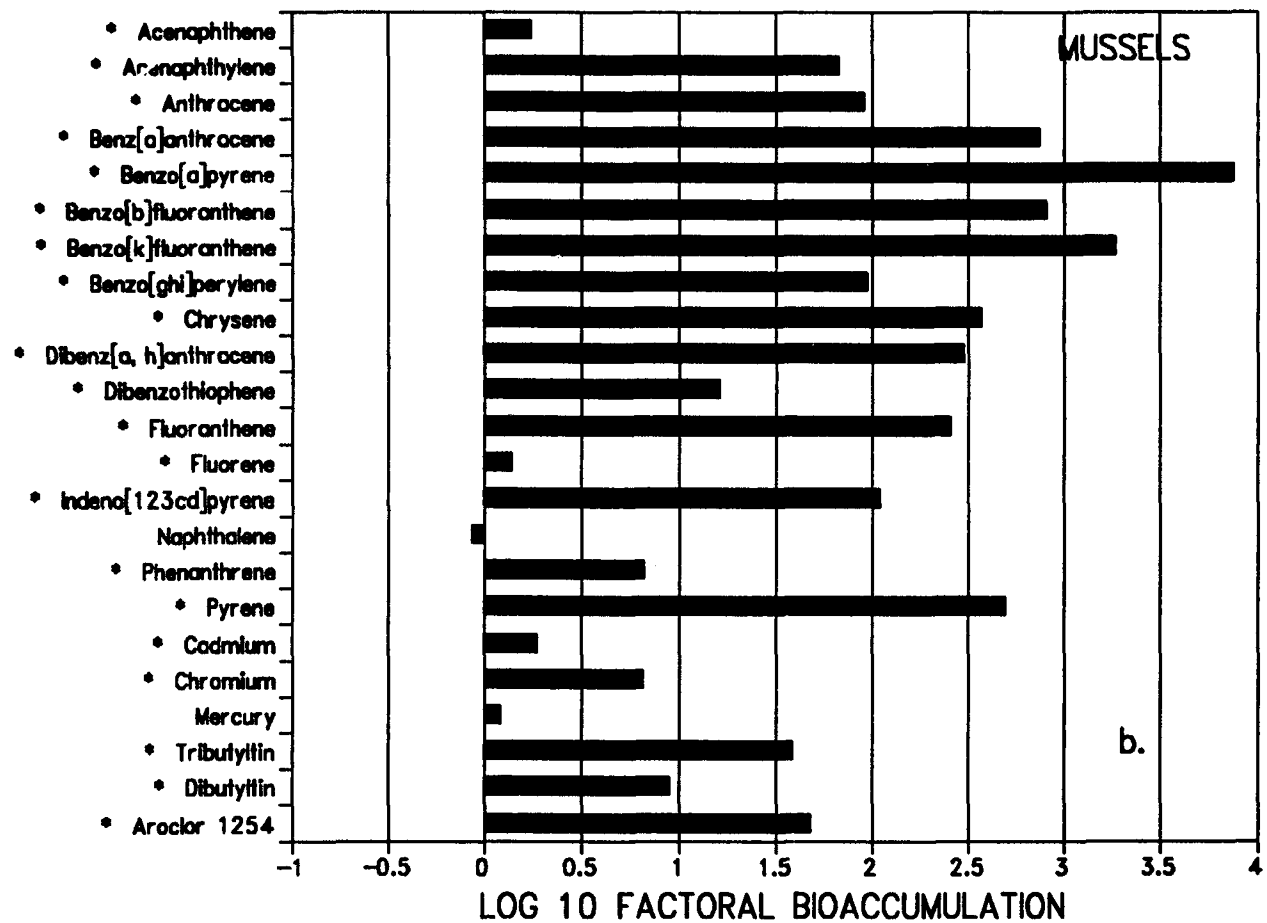

Figure B51. Bioaccumulation in mussels exposed to Hot S50 for 28 days. Log_{10}([exposed]/[background])

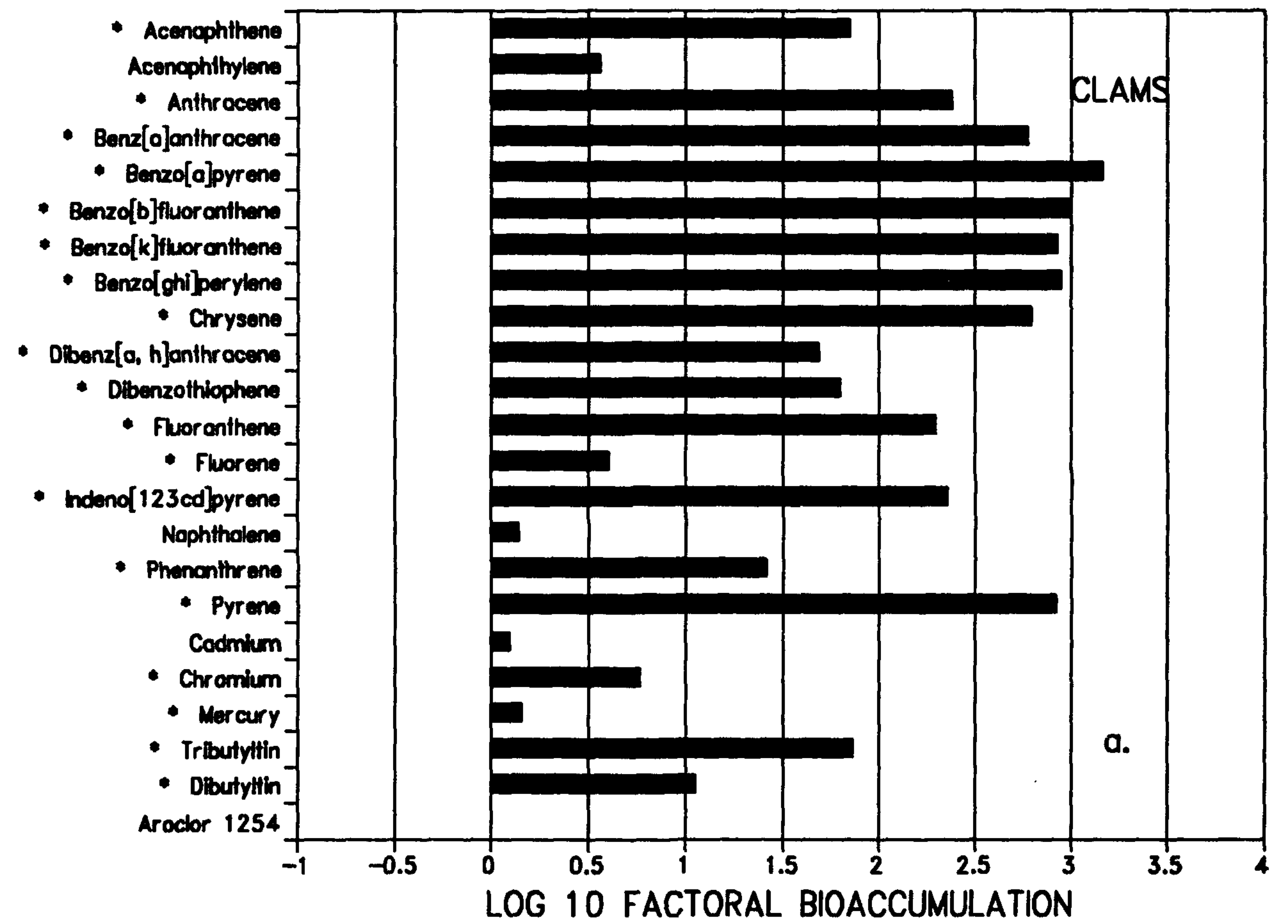

Figure B52. Bioaccumulation in clams exposed to Hot BS for 28 days. Log_{10}([exposed]/[background])

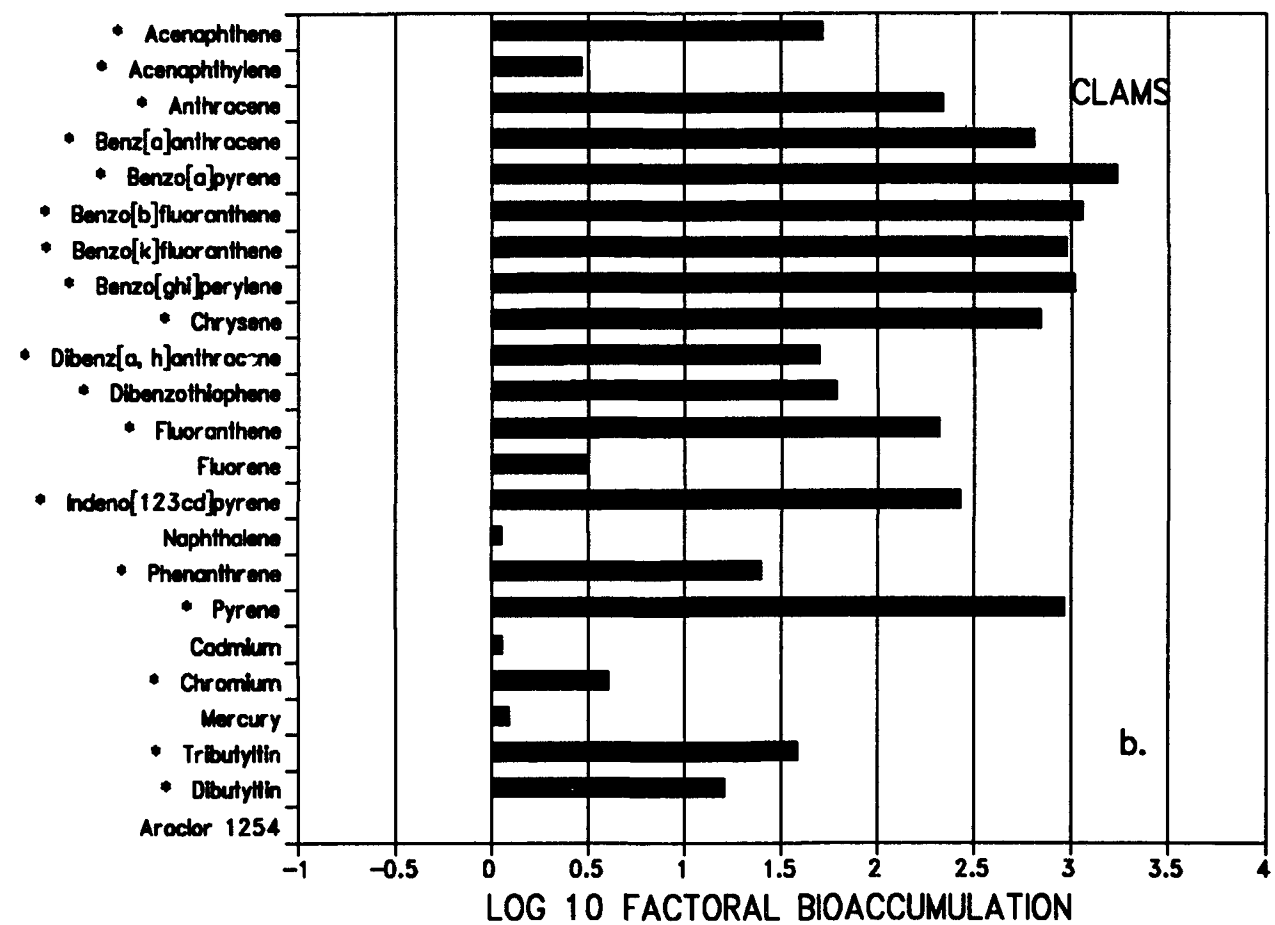

Figure B53. Bioaccumulation in clams exposed to Hot S50 for 28 days. Log_{10}([exposed]/[background])

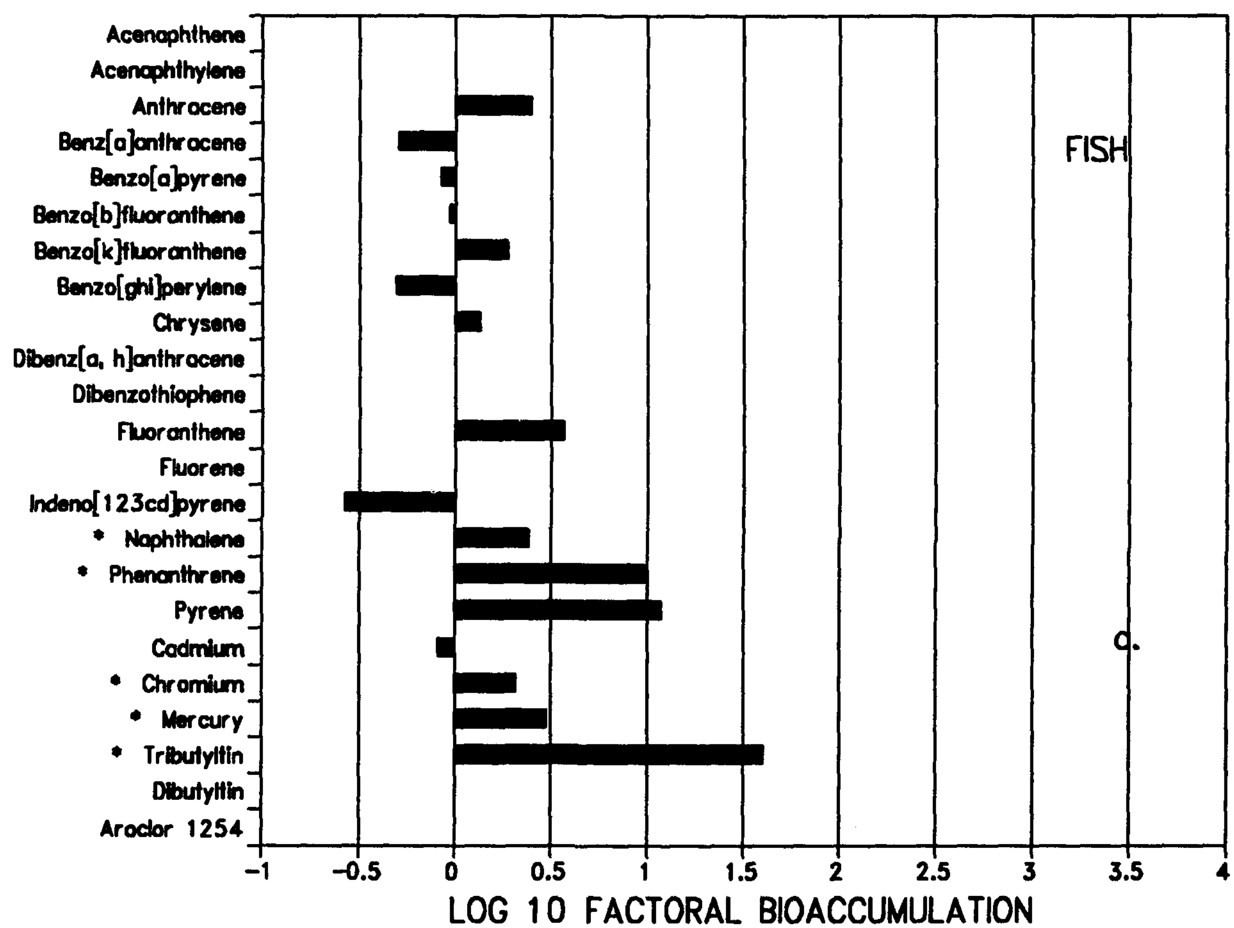

Figure B54. Bioaccumulation in fish exposed to Hot BS for 28 days. Log_{10}([exposed]/[background])

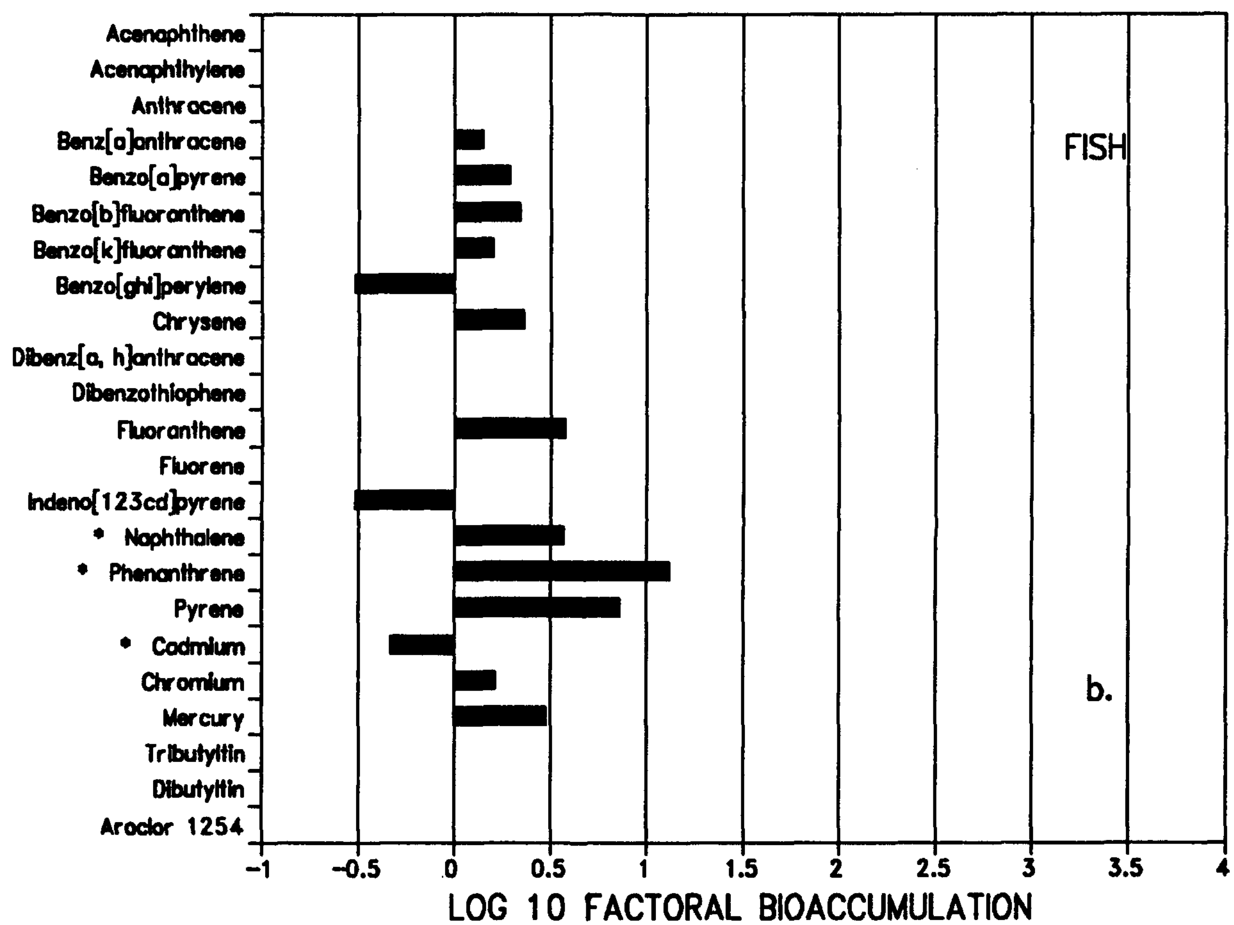

Figure B55. Bioaccumulation in fish exposed to Hot S50 for 28 days. Log_{10}([exposed]/[background])

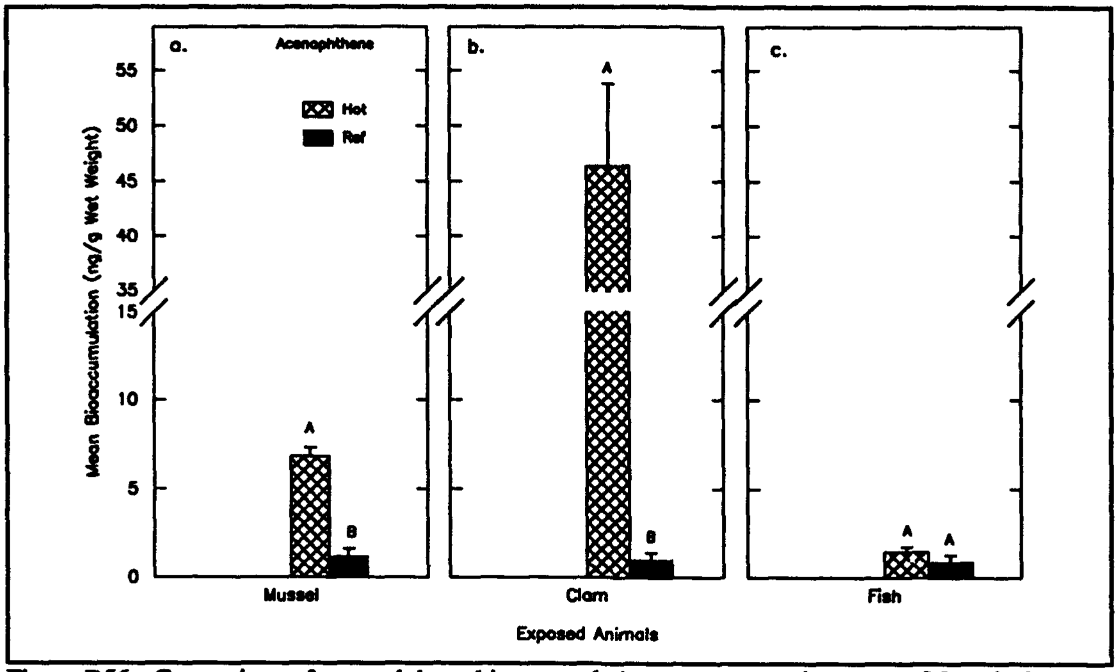

Figure B56. Comparison of acenaphthene bioaccumulation among experiments. a. Mussel. b. Clam. c. Fish. In each box, bars with same letter are not significantly different ($P_{\alpha/2} > 0.025$)

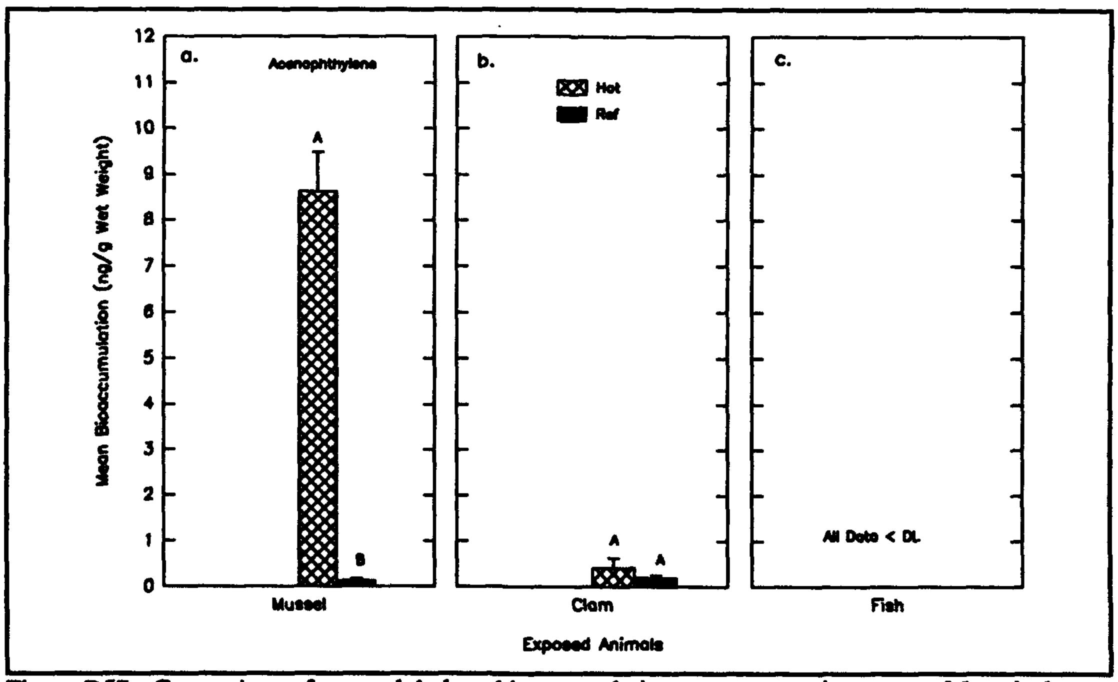

Figure B57. Comparison of acenaphthylene bioaccumulation among experiments. a. Mussel. b. Clam. c. Fish

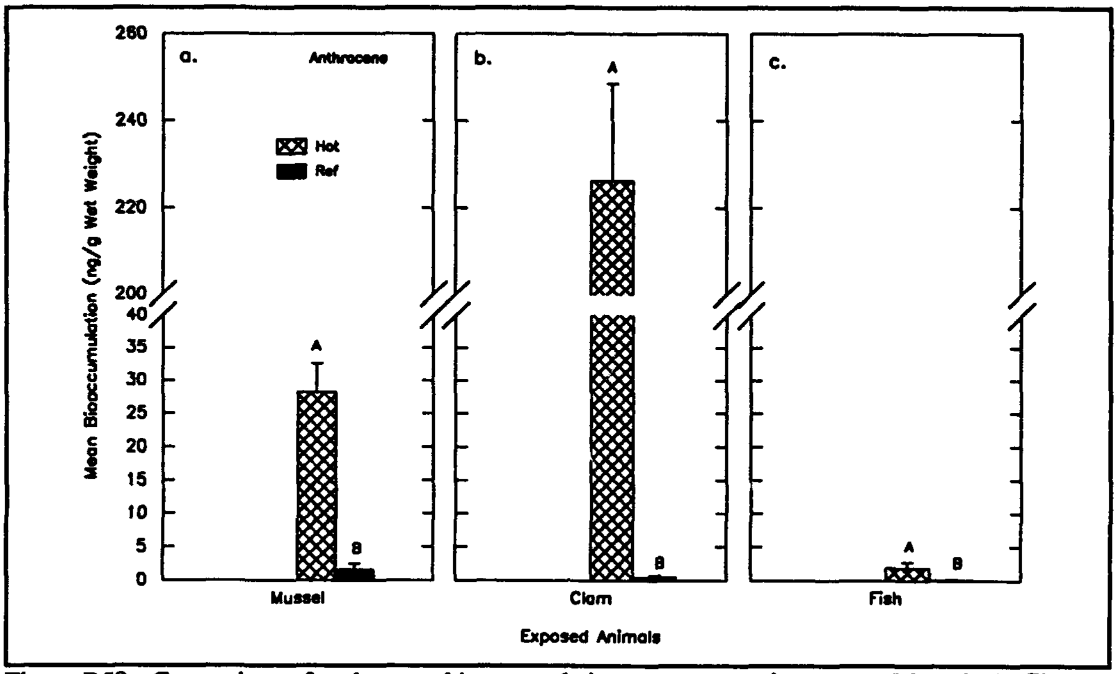

Figure B58. Comparison of anthracene bioaccumulation among experiments. a. Mussel. b. Clam. c. Fish

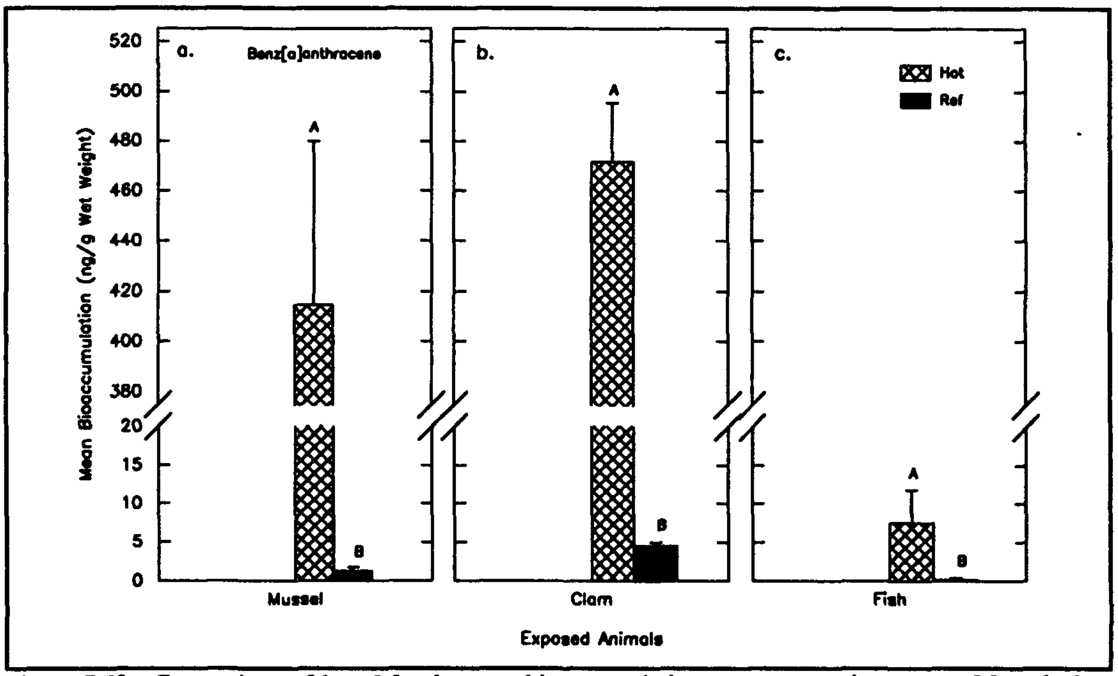

Figure B59. Comparison of benz[a]anthracene bioaccumulation among experiments. a. Mussel. b. Clam. c. Fish

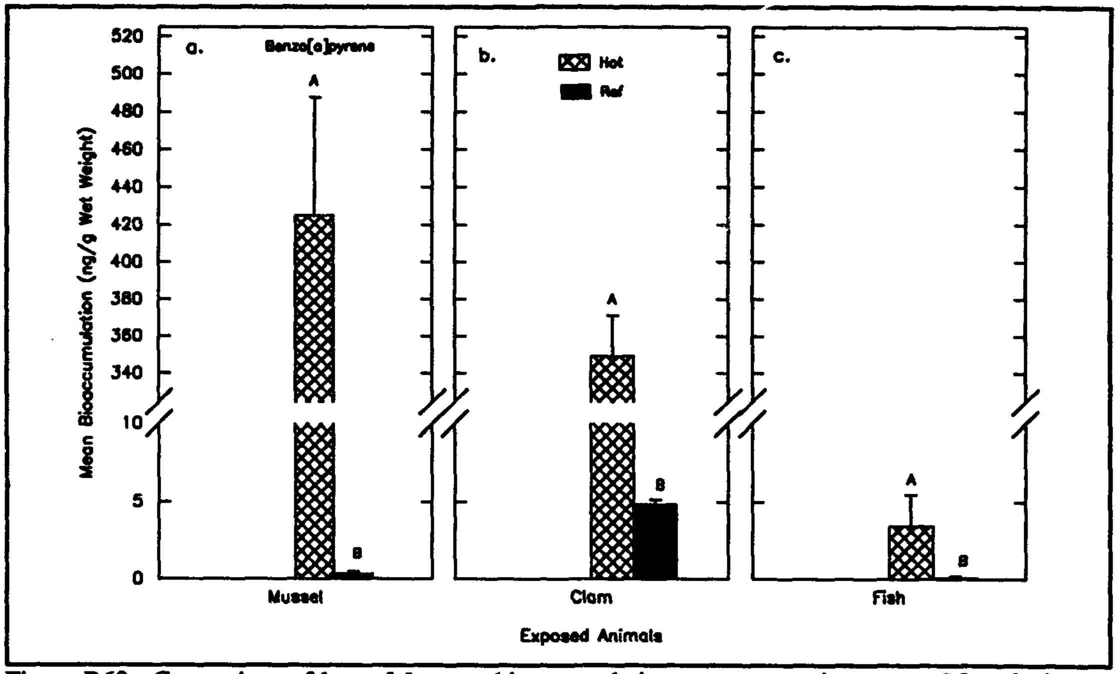

Figure B60. Comparison of benzo[a]pyrene bioaccumulation among experiments. a. Mussel. b. Clam. c. Fish

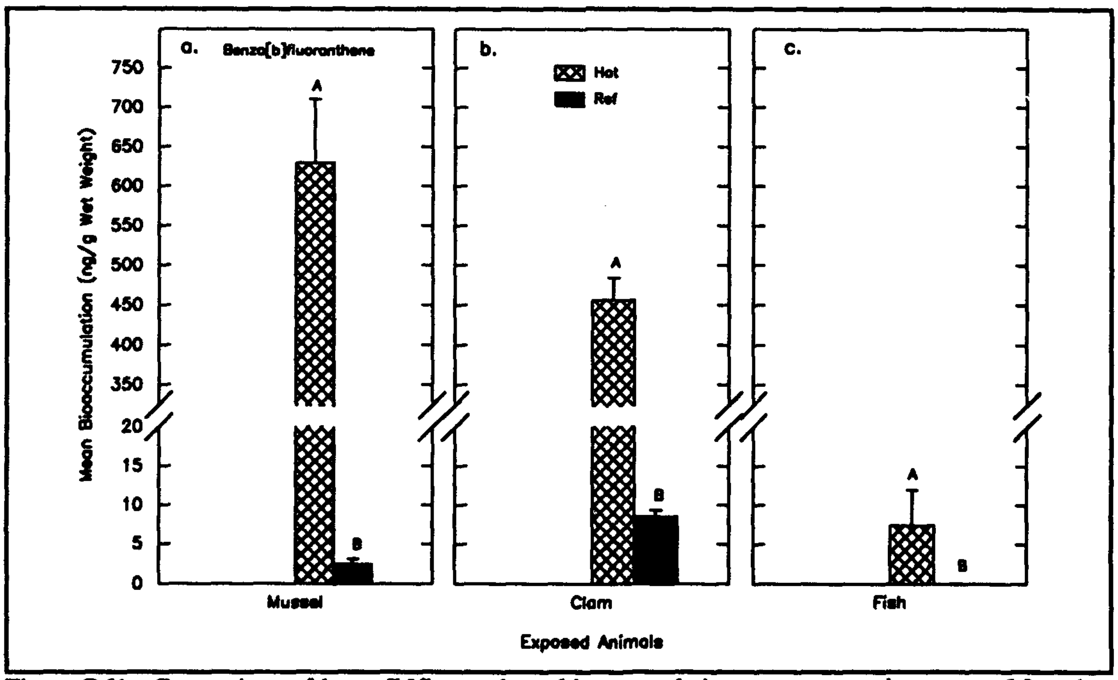

Figure B61. Comparison of benzo[b]fluoranthene bioaccumulation among experiments. a. Mussel. b. Clam. c. Fish

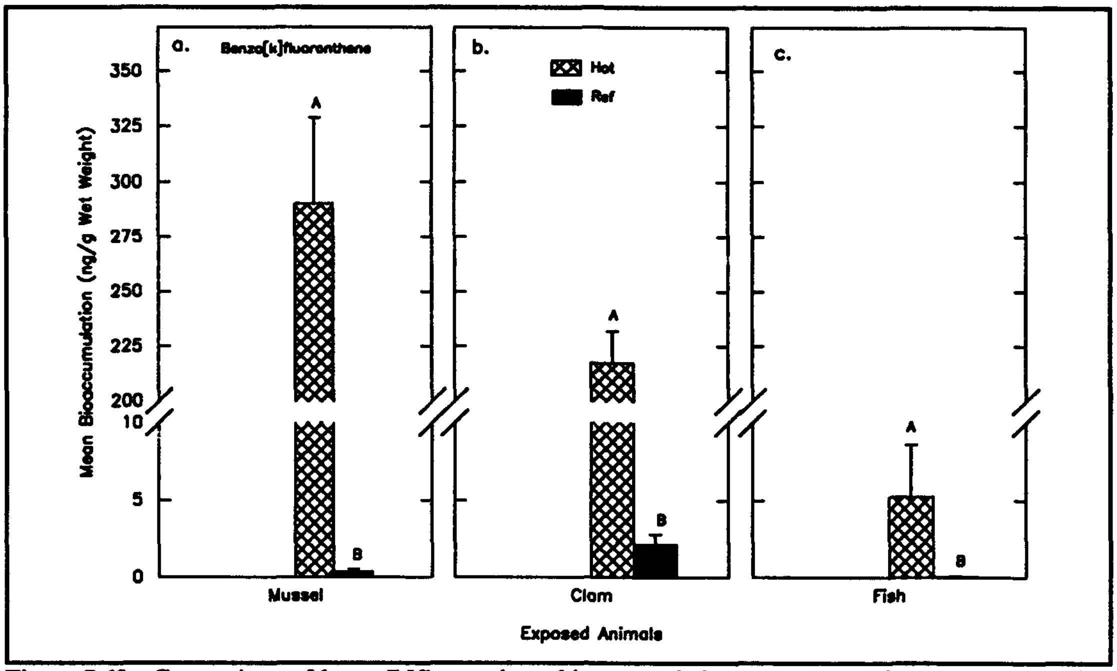

Figure B62. Comparison of benzo[k]fluoranthene bioaccumulation among experiments. a. Mussel. b. Clam. c. Fish

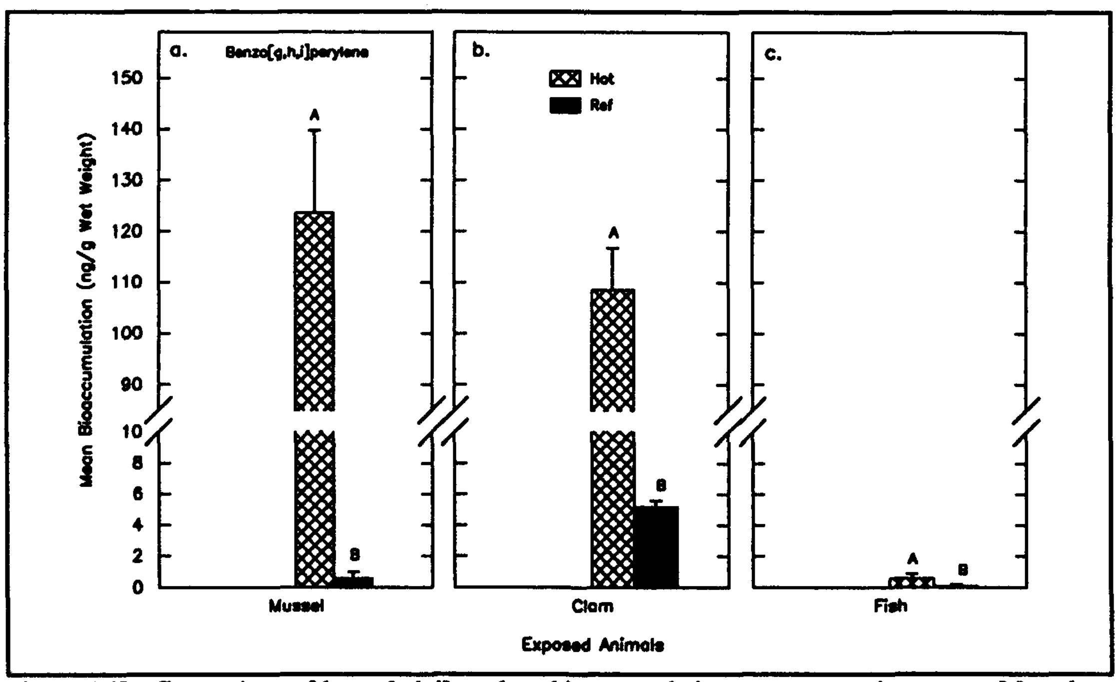

Figure B63. Comparison of benzo[g,h,i]perylene bioaccumulation among experiments. a. Mussel. b. Clam. c. Fish

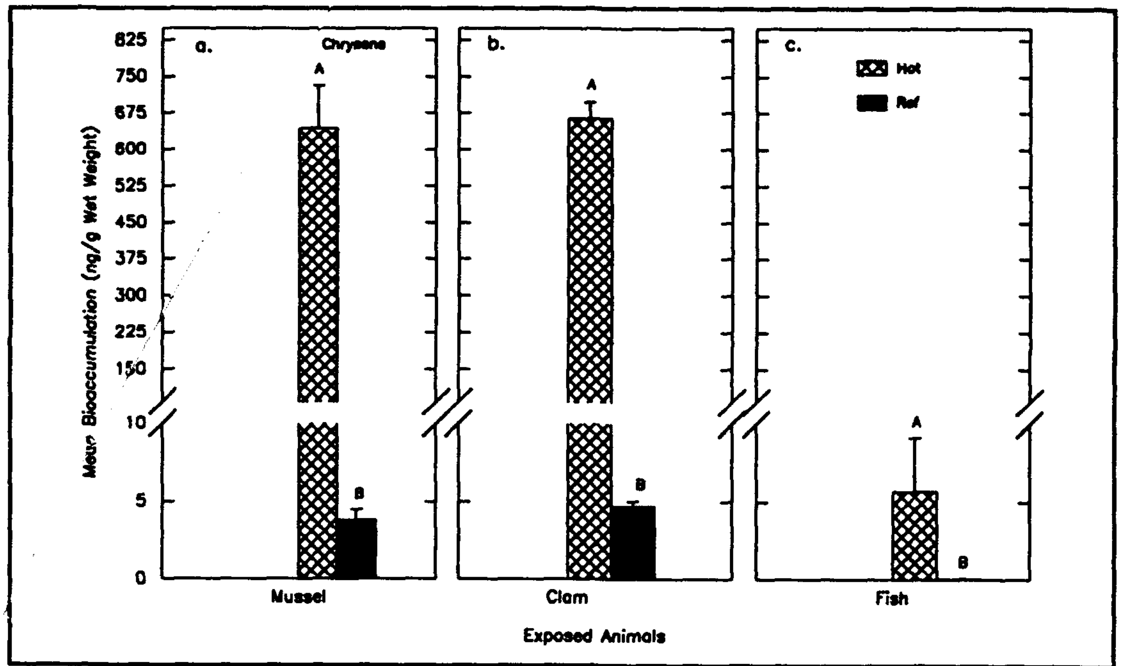

Figure B64. Comparison of chrysene bioaccumulation among experiments. a. Mussel. b. Clam. c. Fish

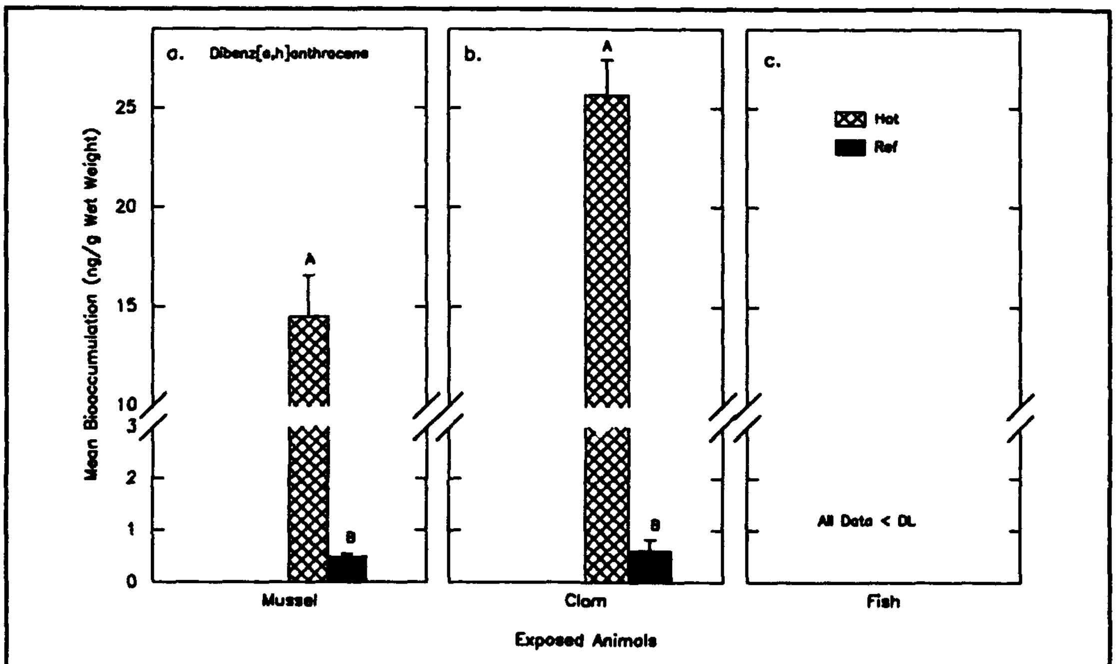

Figure B65. Comparison of dibenz[a,h]anthracene bioaccumulation among experiments. a. Mussel. b. Clam. c. Fish

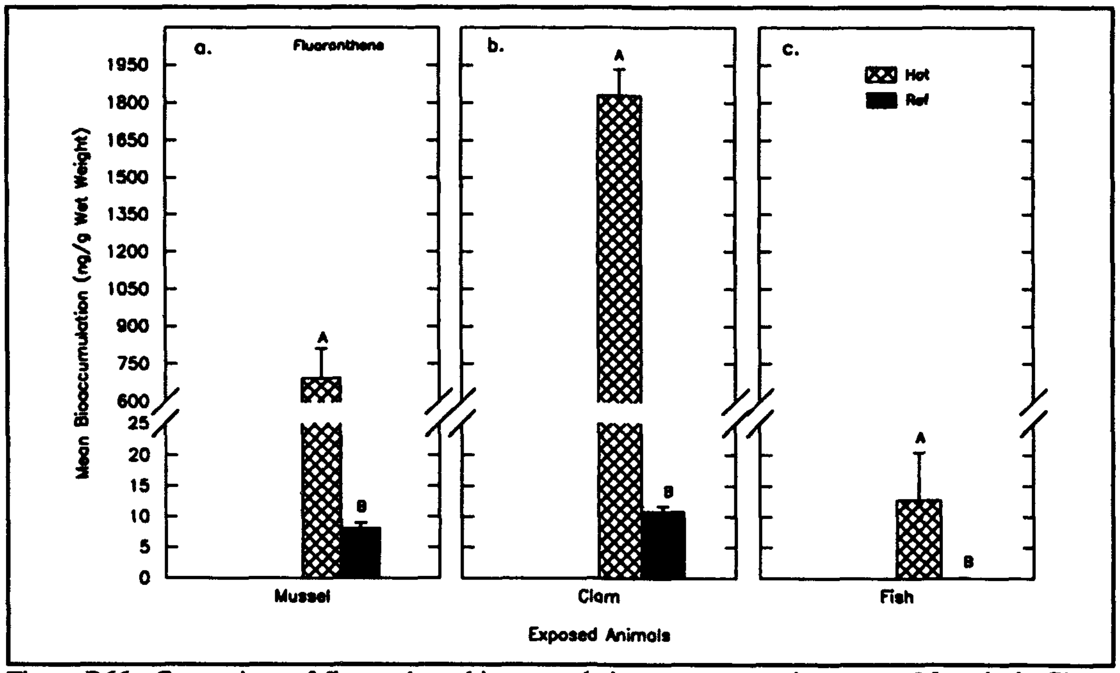

Figure B66. Comparison of fluoranthene bioaccumulation among experiments. a. Mussel. b. Clam. c. Fish

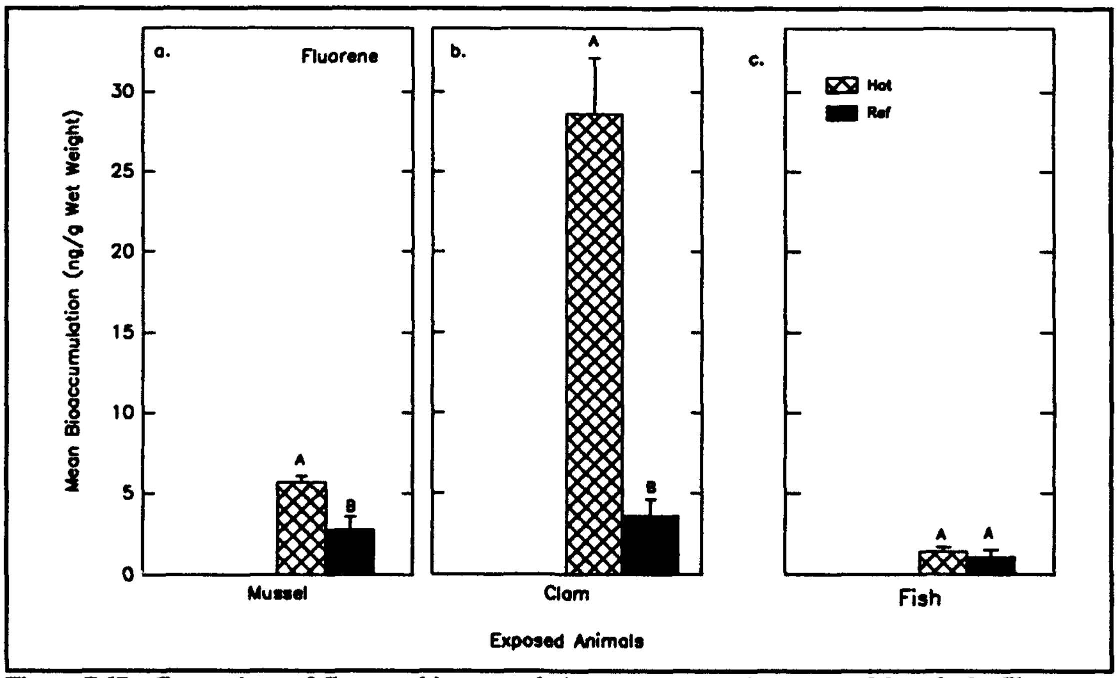

Figure B67. Comparison of fluorene bioaccumulation among experiments. a. Mussel. b. Clam. c. Fish

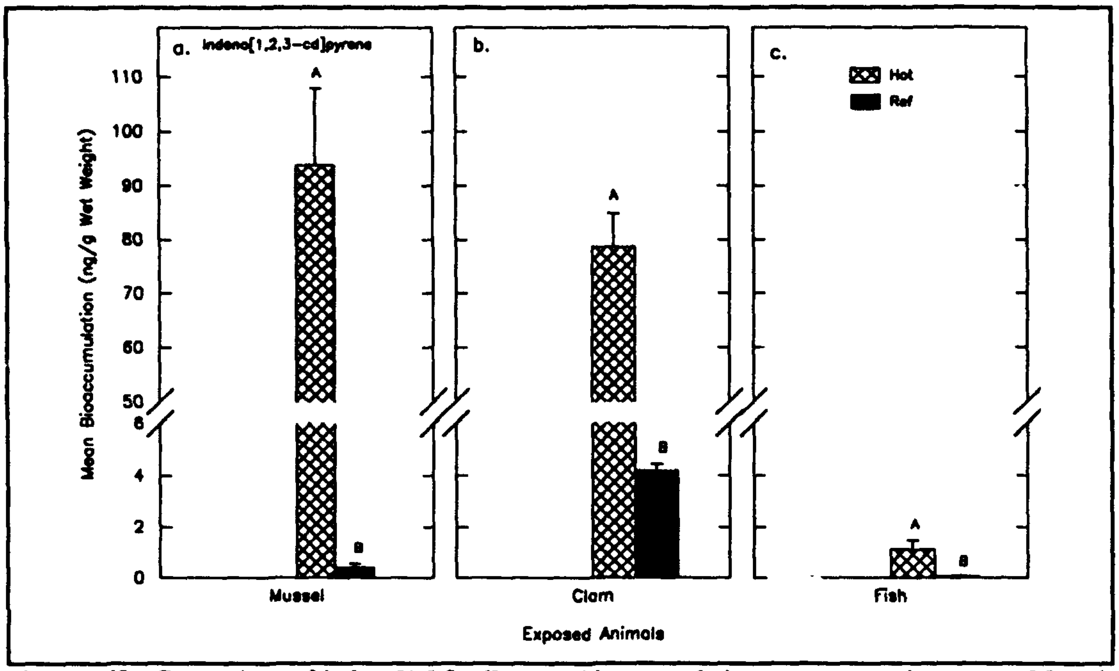

Figure B68. Comparison of indeno[1,2,3-cd]pyrene bioaccumulation among experiments. a. Mussel. b. Clam. c. Fish

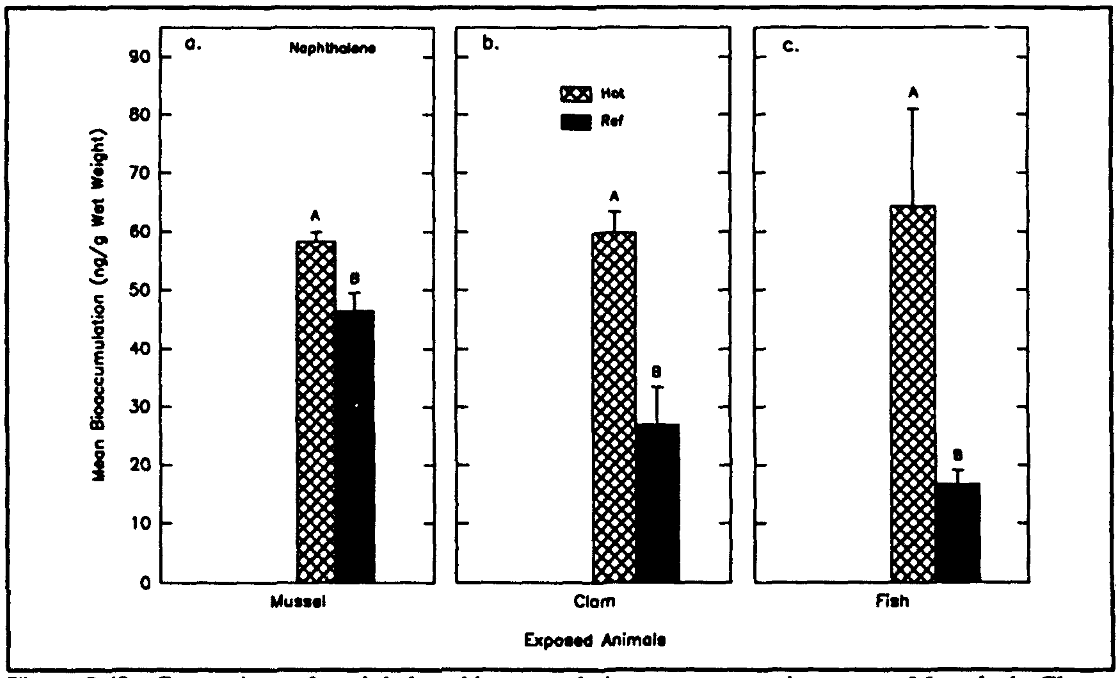

Figure B69. Comparison of naphthalene bioaccumulation among experiments. a. Mussel. b. Clam. c. Fish

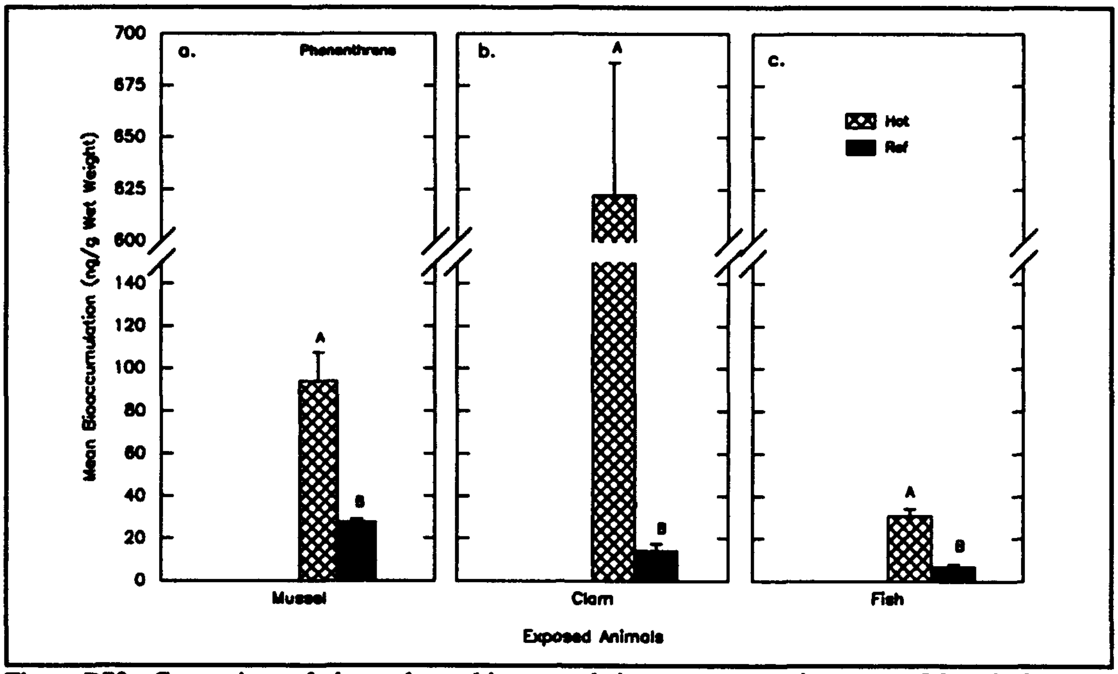

Figure B70. Comparison of phenanthrene bioaccumulation among experiments. a. Mussel. b. Clam. c. Fish

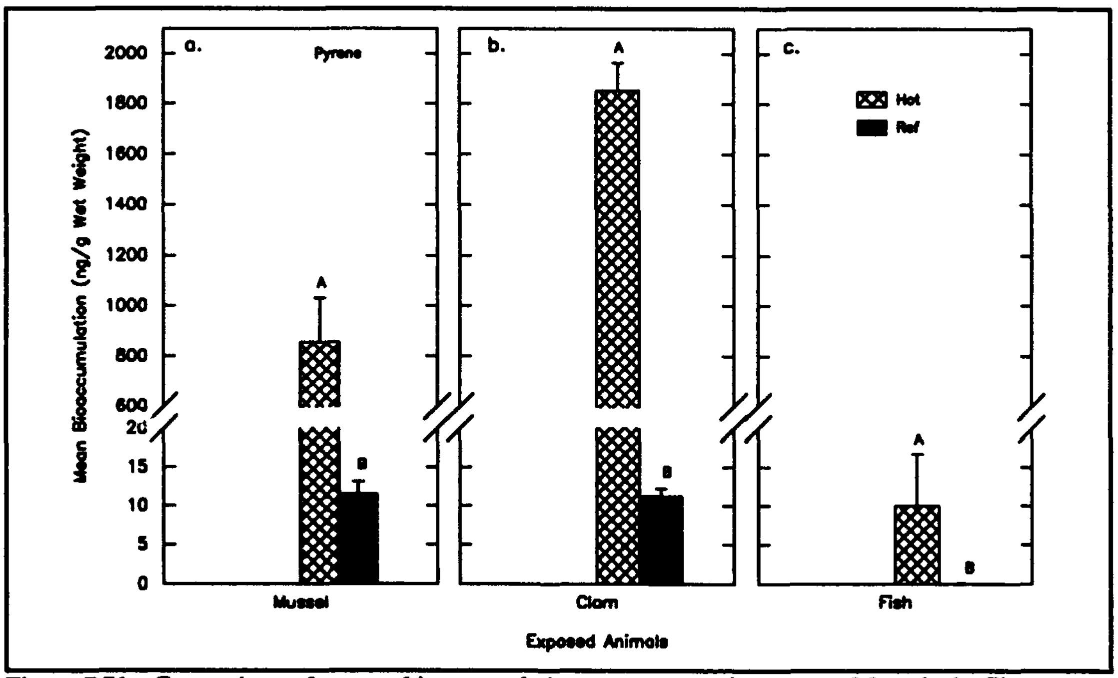

Figure B71. Comparison of pyrene bioaccumulation among experiments. a. Mussel. b. Clam. c. Fish

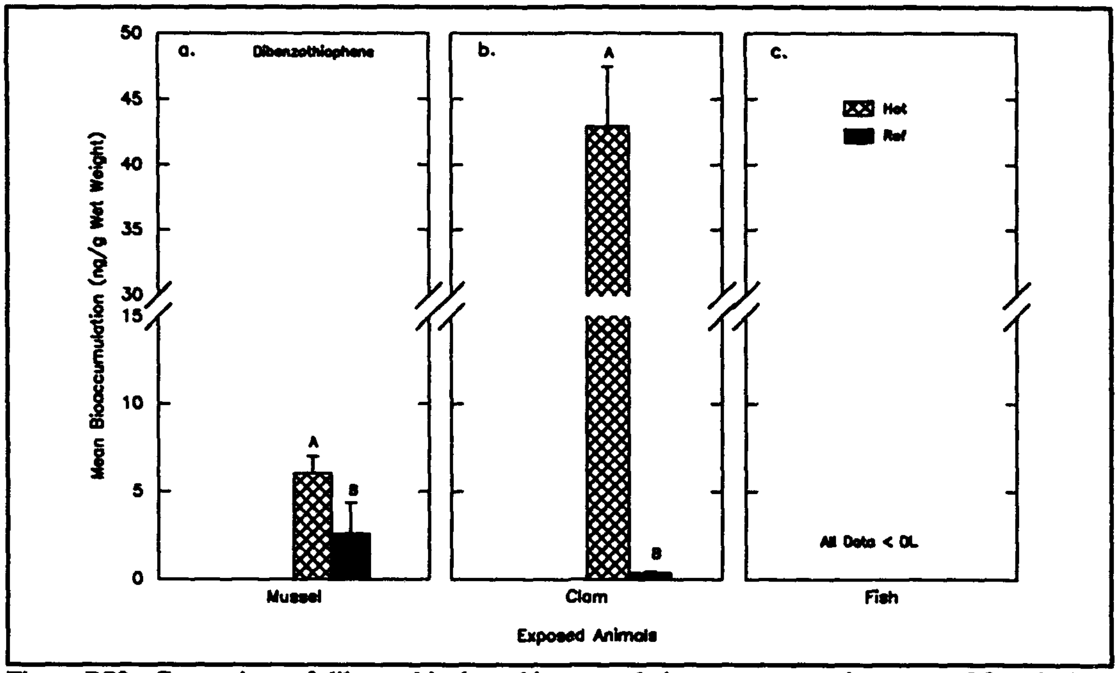

Figure B72. Comparison of dibenzothiophene bioaccumulation among experiments. a. Mussel. b. Clam. c. Fish

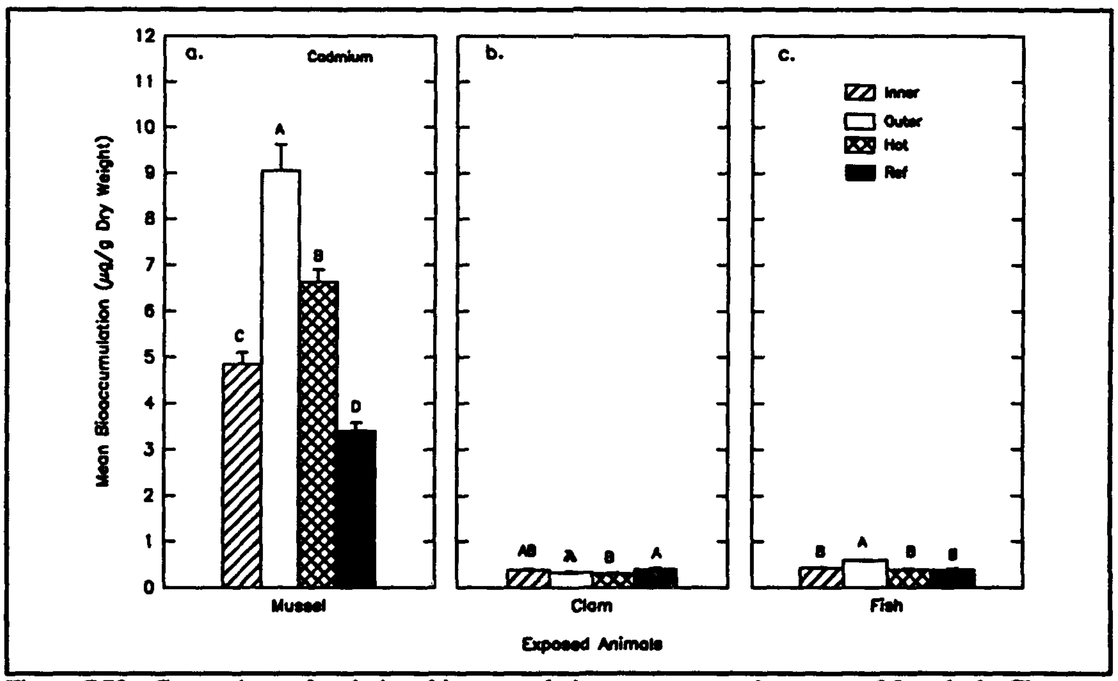

Figure B73. Comparison of cadmium bioaccumulation among experiments. a. Mussel. b. Clam. c. Fish

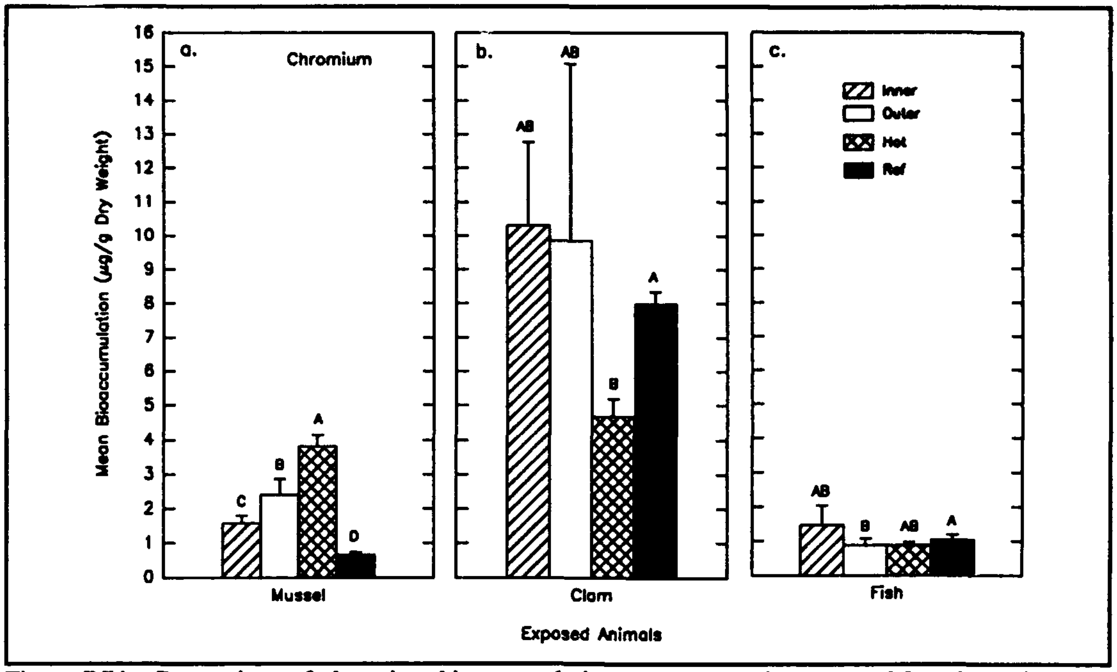

Figure B74. Comparison of chromium bioaccumulation among experiments. a. Mussel. b. Clam. c. Fish

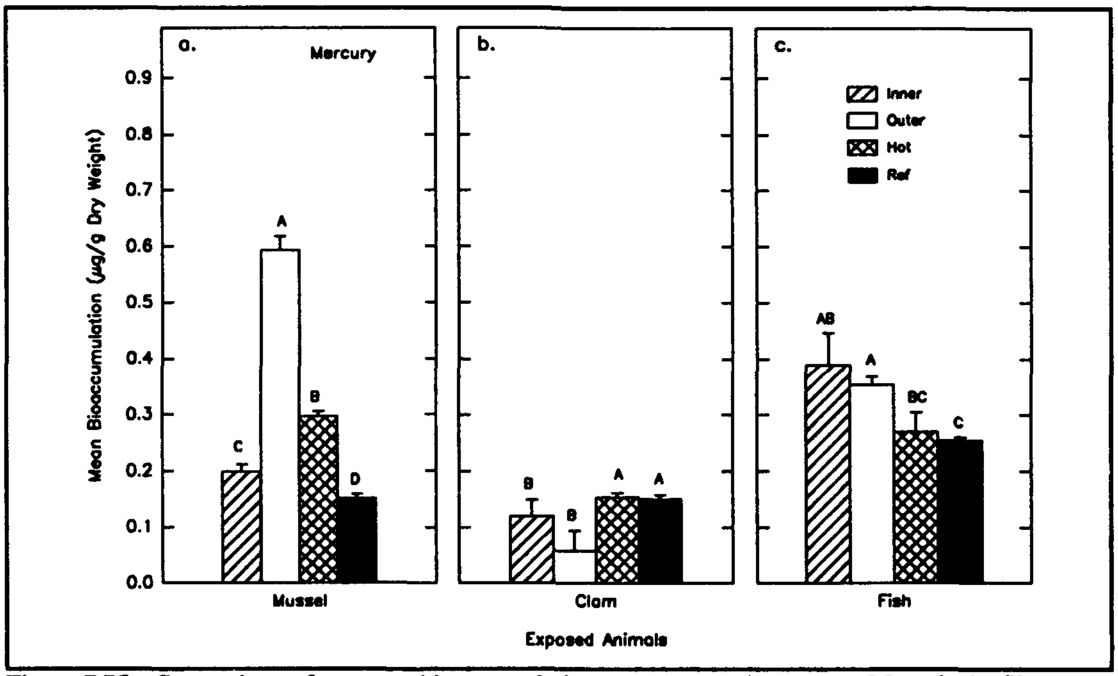

Figure B75. Comparison of mercury bioaccumulation among experiments. a. Mussel. b. Clam. c. Fish

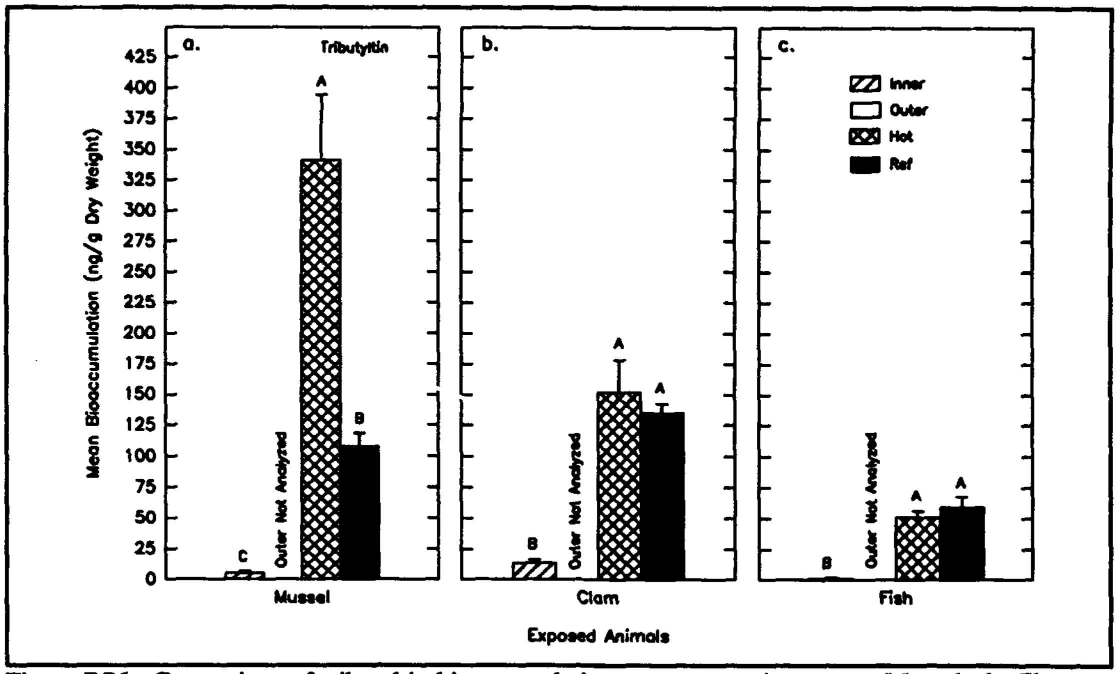

Figure B76. Comparison of tributyltin bioaccumulation among experiments. a. Mussel. b. Clam. c. Fish

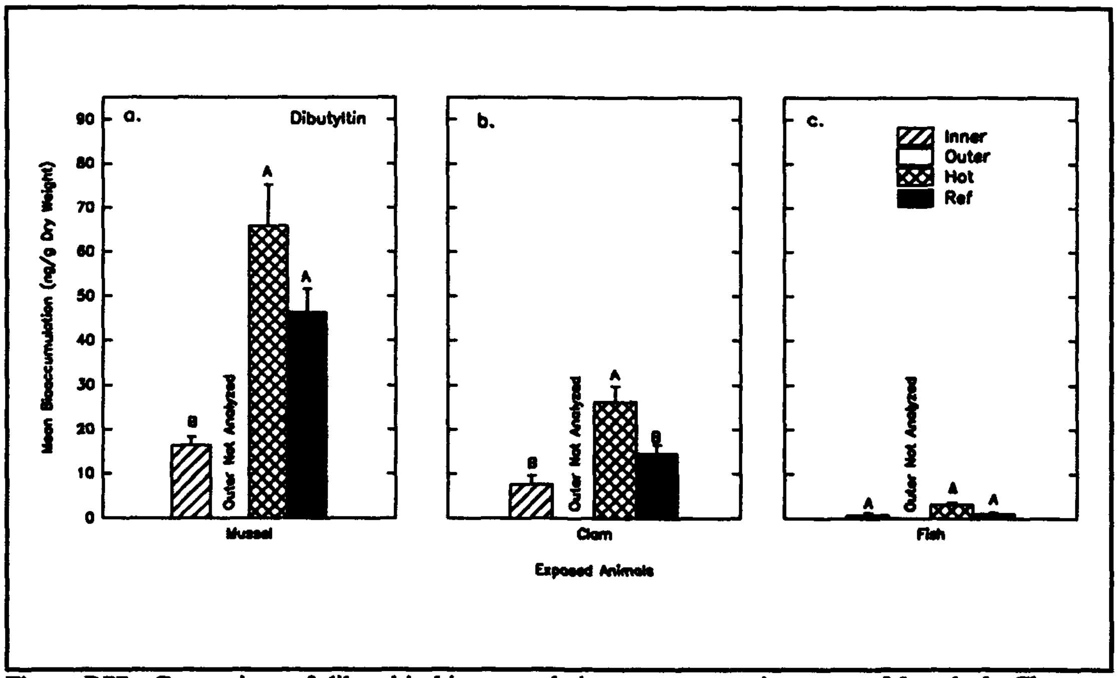

Figure B77. Comparison of dibutyltin bioaccumulation among experiments. a. Mussel. b. Clam. c. Fish

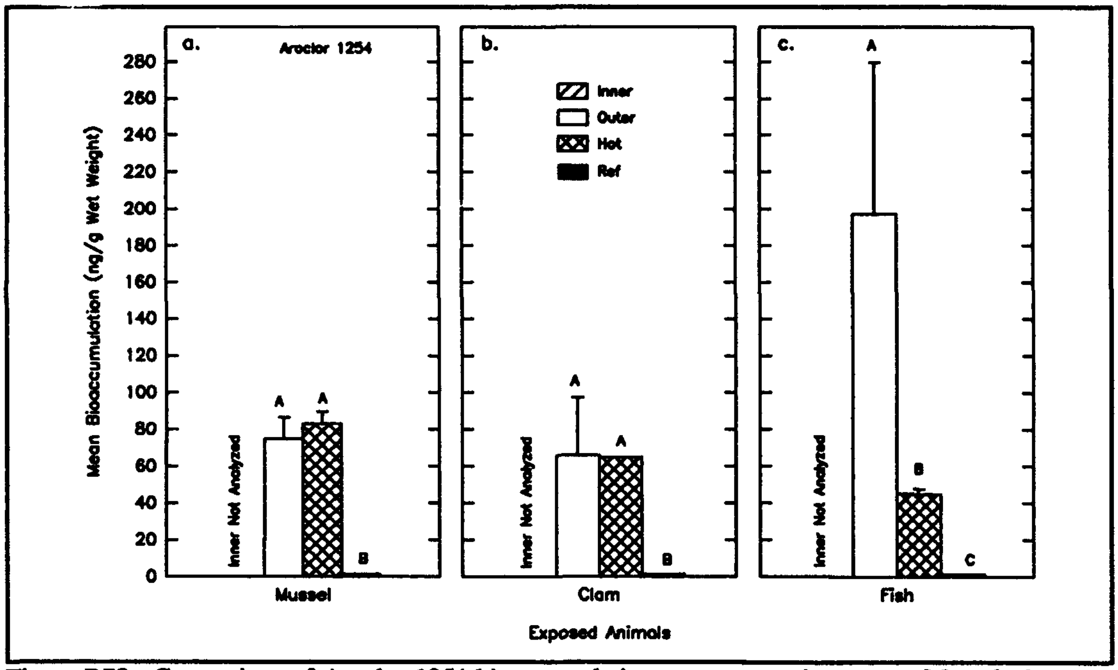

Figure B78. Comparison of Aroclor 1254 bioaccumulation among experiments. a. Mussel. b. Clam. c. Fish

Appendix C

Notation

‰	parts per thousand
α	significance level for a statistical test
Acn	acenaphthene
ACT	Aquatic Contaminants Team, WES
Acy	acenaphthylene
AF	accumulation factor
Ag	silver
ALG	Analytical Laboratory Group, WES
An	anthracene
ANOVA	analysis of variance
Ar_2	argon gas
As	arsenic
B[a]A	benz[a]anthracene
B[a]P	benzo[a]pyrene
BF	benzo[b+k]fluoranthene
B[ghi]P	benzo[g,h,i]perylene
BHC	benzene hexachloride (lindane)
BPNL	Battelle Pacific Northwest Laboratories
BS	bedded sediment treatment
°C	degrees Celsius
Cd	cadmium
Chry	chrysene
cm	centimeter
Cr	chromium
C_s	contaminant concentration in sediment
C_t	contaminant concentration in tissue
Cu	copper
CVAA	cold vapor atomic absorption
cy	cubic yards
d	day
DBA	dibenz[a,h]anthracene
DBT	dibutyltin

DCP	direct coupled plasma
DDD	dichloro-diphenyl-dichloroethane
DDE	dichloro-diphenyl-dichloroethylene
DDT	dichloro-diphenyl-trichloroethane
DL	detection limit
d_{min}	minimum detectable difference for a statistical test
DNA	deoxyribonucleic acid
ECD	electron capture detection
EP	exchangeable phase
ERP	easily reducible phase
FATES	Flow-through Aquatic Toxicology Exposure System
FDA	Food and Drug Administration
FL	fluorene
Fla	fluoranthene
f_{lipid}	lipid fraction of an organism
f_{oc}	organic carbon fraction of sediment
g	gram
gal	gallon
GC	gas chromatography
GFAA	graphite furnace atomic absorption
HCl	hydrochloric acid
He	helium
Hg	mercury
hr	hour
I[cd]P	indeno[1,2,3-cd]pyrene
ICP	inductively coupled plasma
i.d.	inner diameter
Kg	kilogram
K_{oc}	organic carbon-water partition coefficient
K_{ow}	octanol-water partition coefficient
L	liter
LC_{50}	concentration lethal to 50 percent of exposed population

LSD	Fisher's Least Significant Difference test
μg	microgram
μl	microliter
μm	micrometer
m	meter
MBT	monobutyltin
mcy	million cubic yards
MDRS	Mud Dump Reference Site
mg	milligram
min	minute
ml	milliliter
MLLW	mean lower low water
mm	millimeter
MS	mass spectrometry
MSL	Battelle Marine Sciences Laboratory
N	Normal
N	total number of observations
n	number of replicates (sample size)
N_2	nitrogen gas
NADPH	nicotinamide adenine dinucleotide phosphate
NaOH	sodium hydroxide
Naph	naphthalene
NC	negative control treatment
ng	nanogram
Ni	nickel
OHDP	Oakland Harbor Deepening Project
P	probability
PAH	polynuclear aromatic hydrocarbon
Pb	lead
PC	positive control treatment
PCB	polychlorinated bipnehyl
pf	preference factor

pg	picogram
Phen	phenanthrene
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
Pyr	pyrene
RWQCB	California Regional Water Quality Control Board
S10	10 mg/L suspended sediment treatment
S50	50 mg/L suspended sediment treatment
SE	standard error
Se	selenium
sec	second
SF	San Francisco
SFD	San Francisco District, U.S. Army Corps of Engineers
SLC	Screening Level Concentration
SQC	sediment quality criteria
TBP	theoretical bioaccumulation potential
TBT	tributyltin
TCDD	tetrachlorodibenzo-*p*-dioxin
TeBT	tetrabutyltin
TEF	toxicity equivalency factor
TOC	total organic carbon
TSS	total suspended solids
USAE	U.S. Army Engineer
wt.	weight
Zn	zinc

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13. ABSTRACT *(Maximum 200 words)*

The Oakland Harbor Deepening Project (OHDP) has been on hold since 1987 due to public and resource agency concerns regarding further disposal of dredged sediments within San Francisco (SF) Bay. Dispersal of the fines fraction throughout the Bay was thought to occur following disposal operations at the Alcatraz site, resulting in transport of contaminants throughout the Bay system. The study described in this report was designed to address the potential for contaminant uptake in estuarine organisms through exposure to suspended and bedded OHDP sediments. Bioaccumulation that occurred from these sediments was put into perspective with bioaccumulation from sediments normally resuspended in the Bay by natural processes, and from a demonstrably contaminated sediment. Indigenous SF Bay organisms were exposed to either bedded or suspended sediment in replicate experimental units of the Flow-through Aquatic Toxicology Exposure System (FATES) at the WES. Sediments and tissues were analyzed for a suite of contaminants, including organotins, polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides and DDE, and ten metals.

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Bioavailability of contaminants was determined by comparing tissue concentrations in each of the three species (clams, mussels, fish) after 28-day exposure, with background tissue concentrations taken immediately prior to the start of exposure. Bioavailable contaminants from the OHDP sediments were limited to Cd (Outer Harbor), Cr (Inner and Outer Harbor), and tributyltin (Inner Harbor). Most contaminants that bioaccumulated achieved remarkably similar tissue concentrations, particularly in the clams, from either bedded or suspended sediment exposures.

Results of this bioaccumulation study suggest that disposal of OHDP Inner and Outer sediments at in-Bay aquatic disposal sites is unlikely to increase contaminant bioaccumulation above that which already occurs from naturally resuspended sediments.